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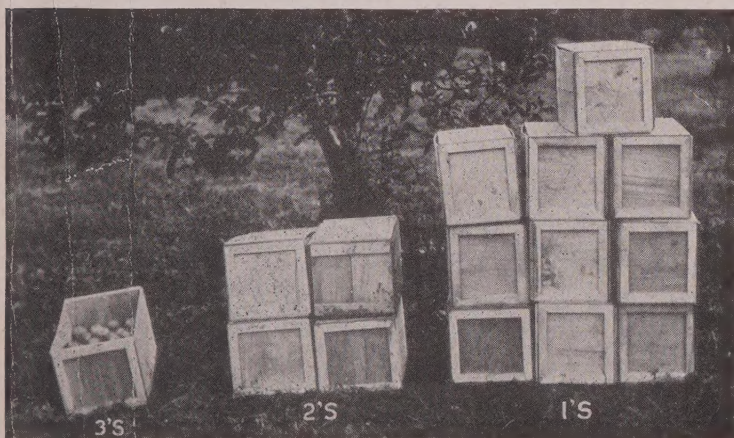
OF

NEBRASKA

SPRAYING EXPERIMENTS IN NEBRASKA

BY J. RALPH COOPER

DISTRIBUTED APRIL 10, 1917



FRUIT FROM A SPRAYED TREE GRADED INTO FIRSTS, SECONDS, AND THIRDS

LINCOLN, NEBRASKA
U. S. A.

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SPRAYING EXPERIMENTS IN NEBRASKA

J. RALPH COOPER

INTRODUCTION

Spraying experiments were begun in Nebraska in 1906 by the Experiment Station in coöperation with the United States Department of Agriculture. The results of the first year's work were published in Bulletin 98, "Spraying Demonstrations in Nebraska Apple Orchards." In 1907 the Experiment Station continued the work alone and published the results in Bulletin 106, "Does It Pay to Spray Nebraska Apple Orchards?" In 1908 the Experiment Station and the United States Department of Agriculture again conducted the work jointly, and in 1909 and 1910 the Experiment Station continued the work alone. A report of this work was made in Bulletin 119, "Spraying as an Essential Part of Profitable Apple Orchardling."

In 1913 work was begun on a much larger scale by the Experiment Station coöperating with the Extension Service in an attempt to demonstrate known methods and evolve new methods of practice from a commercial as well as an experimental standpoint and which would apply to the solution of spraying problems as they might arise from time to time.¹

The more important questions which were considered during the three years covered by the present report were as follows:

1. How many summer sprays are required and when should they be applied?
2. What is the difference in efficiency between various brands of arsenate of lead?
3. What are the relative values of lime sulphur and Bordeaux as fungicides for spraying apples?
4. Is it possible to lessen or prevent Bordeaux injury and at the same time control fungous diseases?
5. Is it possible to interchange Bordeaux and lime sulphur in a spray schedule in such a manner as to secure better results than by using either fungicide for the complete schedule?
6. Is home boiled lime sulphur as efficient as the ordinary commercial brands of concentrated lime sulphur?
7. Of what value are certain new fungicides and insecticides as summer sprays for apples?

¹The work was placed directly in charge of the writer, three-quarters of his salary being paid by the Experiment Station and one-quarter of his salary and all traveling expenses being paid by the Extension Service. The Extension Service also paid the salaries and traveling expenses of the assistants, while the Experiment Station furnished all materials not furnished by the orchard owners.

8. In what manner should the spray be applied,—as a fine mist or as a coarse, driving spray?

9. Does it pay, commercially, to use both an insecticide and a fungicide at every application?

10. Are the effects of spraying noticeable for longer than one season; i. e., are they cumulative?

11. What effect does clean culture have on disease and insect control?

12. What capacity machine is most economical for the various sizes of orchards ranging from the small home orchard to the largest commercial orchards?

ORGANIZATION

In order to secure results which would be thoroly reliable, it was deemed necessary to conduct field experiments in orchards located in different parts of the State and in a number sufficient to include as nearly as possible all the different conditions under which fruit growing is carried on. In order to overcome seasonal differences, it was planned to conduct experiments in these representative districts for a series of years.

Six orchards were selected in 1913,—one at Wymore owned by Lake Bridenthal; one at Nemaha, owned by John Smith; one at Brownville, owned by Fred Lewis; one at Florence, owned by J. J. Smith; one at Florence, owned by L. Abbott¹; and the Experiment Station orchard at Lincoln.

In 1914 the orchards at Wymore and Brownville were retained and new ones selected, as follows: One at Beatrice, owned by E. J. Kessler; one at Lincoln, operated by A. N. Ohler; and one at Seward, owned by Allen Hickman.

In 1915 the orchards at Beatrice and Lincoln were retained and one new one selected near Omaha, owned by G. H. Beavers.

In all cases the work was done in coöperation with the orchard owners. At Beatrice and Wymore the work was done in co-operation with County Agricultural Agent O. H. Liebers and at Seward with County Agricultural Agent A. H. Beckhoff.

In 1913 the writer was assisted in the work by H. W. Richey, a graduate of the University of Nebraska; in 1914 by W. W. Downing, a graduate of Iowa State College; and in 1915 by E. H. Hoppert, a graduate of the University of Wisconsin, now Extension specialist with the University of Nebraska. The accompanying map shows the location of the various experiments conducted during the last three years.

In choosing the orchards, special care was taken to secure those representative of the sections in which they were located, which

¹The data taken in Mr. Abbott's orchard were not used, because part of the fruit was picked by mistake and no records were kept.

were of uniform vigor and variety, and which were of such size and shape and planted in such a way that they would lend themselves to platting for experimental work.

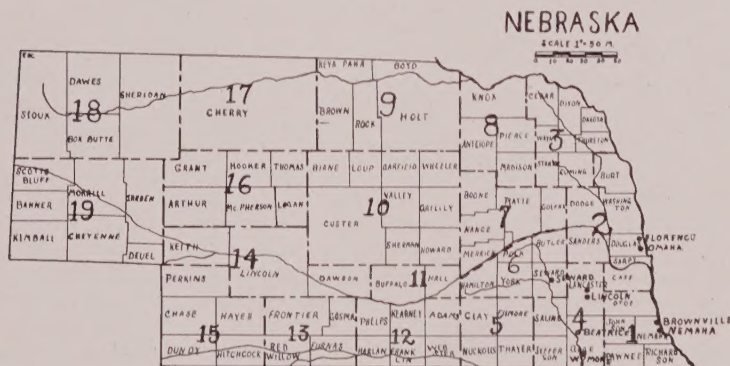


Fig. 1.—Map showing location of experimental orchards

In order that the results might be thoroly reliable, and to overcome individual variation, a large number of trees were included in each plat, the number being in each case what could be conveniently sprayed with one load, except in cases where barrel sprayers were used, when two or more barrels of spray were used on the same plat. After the fruit was set, from four to twelve trees were selected, as nearly uniform in all respects as possible, from which to examine the fruit.

Trees were left unsprayed in each plat as a "check"¹ whenever possible. It was necessary to select the "check" trees before the fruit set and before the selection of the "count"² sprayed trees, but enough were left in practically all cases so that those which were not comparable could be discarded.

However, in spite of the utmost care, difficulties presented themselves from time to time. One of the greatest difficulties lay in the individual variation of trees. Another difficulty was the very noticeable variation in amount of disease infection and insect infestation in various parts of the same orchard. To counteract these variations, "checks" and "count" trees were selected as near together as possible in various places thruout the plats.

¹"Checks" are the trees which were not sprayed.

²"Count" trees are those which were selected for special observation, the fruit being examined and counted for records.

It was very difficult to spray all of the trees exactly alike. To overcome this difficulty, one of the above mentioned men or the writer was present and directly supervised the weighing, mixing, and application of each spray for every plat.

Perhaps one of the greatest troubles encountered was the adoption of a uniform system of taking data and making records. The many degrees of insect, fungous, and spray injuries make it very difficult for different men to make uniform records because of different degrees of importance they may attach to each. This was overcome to a great extent by the writer working with each man thruout as much of the season as possible.

Especially during the season of 1915, russet appeared on the fruit of the check trees so that it was sometimes hard to distinguish between this and spray injury. Often where two unsprayed trees of the same variety stood side by side the fruit on one would be russeted and that on the other comparatively free. An attempt was made to overcome this by averaging the amount of russet on unsprayed trees, accepting this as a standard, and calling all over this amount, on the sprayed trees, spray injury.

INSECTS AND DISEASES CONSIDERED

The principal insects affecting apples in Nebraska are the codling moth (*Carpocapsa pomonella*) and the plum curculio (*Conotrachelus nenuphar*). There are numerous other foliage and fruit eating insects of minor importance, but they are controlled incidentally by the sprays intended for the former. The principal diseases affecting apples are apple scab (*Venturia inaequalis*) and apple blotch (*Phyllosticta solitaria*). As in the case of insects, there are many diseases of minor importance affecting the fruit and foliage of the apple which are usually controlled by sprays intended for the two principal diseases.

Occasionally serious outbreaks of cedar rust (*Gymnosporangium macropus*) occur in localities where large numbers of cedar trees are found near the orchards, but during the last three seasons practically no cedar rust has been noted. In wet seasons, sooty blotch (*Leptothyrium pomi*) often causes considerable damage.

TERMINOLOGY AND EXPLANATION

Bordeaux—The term "Bordeaux" is used thruout this report in place of Bordeaux mixture.

Lime sulphur—The term lime sulphur is used in place of lime sulphur solution.

In all tables Bordeaux is indicated by the letters Bx, lime sulphur by LS, arsenate of lead by Pb.

In indicating the formula when Bordeaux is used, 50 gallons

is the unit adopted, and the amount of the ingredients, expressed in pounds, precedes these figures, separated by dashes. The amount of copper sulphate is expressed first, then the amount of lime, and coming last the figures which show the total amount of solution; thus, Bx-3-4-50 indicates that three pounds of copper sulphate and four pounds of lime were diluted to 50 gallons, while $\frac{\text{Bx-Pb}}{3-4-2-50}$ indicates that two pounds of arsenate of lead was used with the Bordeaux.

In indicating the formula for lime sulphur, the same total unit, 50 gallons, is used, and either the amount of lime sulphur is expressed in gallons, or the total amount of solution is not mentioned and the strength of the solution, diluted and ready for use, is indicated by specific gravity; thus, LS-1½-50 indicates that one and one-half gallons of commercial lime sulphur was diluted to 50 gallons, while $\frac{\text{LS-Pb}}{1\frac{1}{2}-2-50}$ indicates that two pounds of arsenate of lead was used in the solution. By the specific gravity method, LS 1.009 indicates that the commercial lime sulphur was diluted until the specific gravity, as registered by a hydrometer, is 1.009 while $\frac{\text{LS-Pb}}{1.009-2}$ indicates that two pounds of arsenate of lead is added to each 50 gallons of the solution. When arsenate of lead alone is used, the formula is indicated by Pb-2-50.

For the sake of convenience, certain terms are used to designate the spray applications made at different times of the season. The first summer spray, which is applied before the trees are in bloom, is called the cluster-bud spray. The second, which is applied just after the petals have fallen, is called the petal-fall spray. The other applications are called the 7-days spray, the 14-days spray, the 21-days or 3-weeks spray, the 35-days spray, the second-brood spray, and the third-brood or fall spray. The names of the last two indicate that they are for the control of codling moth. This is usually but not always true. In some cases they are solely for the control of fungous diseases but in this report they are in all cases designated as above, regardless of the purpose for which they were employed.

METHODS EMPLOYED

The methods used in attempting to control these insects and diseases were based upon the accumulated experience of workers along this line in all parts of the United States. The machinery, materials, and time and manner of application will be discussed in the report of each experiment.

RECORDS OF RESULTS

In securing data from the various experiments during the years 1913, 1914, and 1915, over one million apples were counted. During the seasons of 1913 and 1914 every apple which set on the trees under observation was examined.¹ In 1915, on account of the extremely heavy set, only a part of the apples from each tree was examined. In examining the windfalls, one hundred apples were picked up under each of four sections of the tree and minutely examined.² All the remaining apples under the tree were picked up and counted, but not examined. To avoid error, all fruits around a certain spot were taken until a hundred had been secured. If there were less than four hundred windfalls, all were examined. At every succeeding examination the places from which apples were picked for examination were changed, so that at several times during the season windfalls from every part of the tree were examined. At picking time, one bushel of fruit was taken from the north, east, south, and west sides and from the top of the tree for examination, and the remaining apples were counted. In computing results, the total number of fruits on the tree were considered at the different percentages of infection or infestation found on the examined portion. Examinations of windfalls and notes on foliage were made as nearly as possible every two weeks from the first part of July until the fruit was harvested.

In examining fruit for blemishes every insect, fungous, or spray injury which would bar an apple from a No. 1 grade was recorded. In grading, the standard adopted by the Department of Horticulture, University of Nebraska, was adhered to.³

¹In examining the apples each one was cut open to be sure no worms were inside.

²Owing to the fact that both insects and fungous diseases operate as a rule early in the season and gradually cease their activities, together with the fact that injured fruit has a tendency to drop early, any records which do not take into account windfalls as well as picked fruit are not a reliable indication of the true conditions.

³*First Grade*—For larger varieties, such as Jonathan, Ben Davis, Black Twig, Arkansas Black, etc., 2½-inch shall be the minimum size. The fruit must be free from insect, fungous, and mechanical injuries. The shape must be characteristic of the variety, and the apple must have 66⅔ per cent of color for a perfectly colored apple of the variety for this region.

For small varieties, such as Winesap, Janet, Ingram, etc., 2¼ inches in diameter shall be the minimum size. The requirements otherwise shall be the same as for larger apples.

Fancy grades of all varieties shall be composed of those apples of the first grade which have 90 per cent color for a perfectly colored apple of the variety for this region.

Second Grade—The minimum size shall be 2¼ inches. Second grade apples shall possess the same physical requirements as to soundness and freedom from insect, fungous, and mechanical injury as the first grade apples.

Second grade apples may deviate slightly from the proper form and may show spray burn if not conspicuous. They must have 33⅓ per cent color for a perfectly colored apple of the variety for this region.

Third Grade—Third grade apples, or salable culls, shall be made up of all apples not included in any of the above grades, free from decay and serious mechanical injury and measuring not less than two inches in diameter.

SPRAYING EXPERIMENTS FOR THE CONTROL OF INSECTS

CODLING MOTH

It has long been known that spraying with arsenical poisons at the proper seasons of the year will almost, if not quite, eliminate codling moth injury, and it is generally conceded that arsenate of lead is the best form in which to employ the poison. However, a great deal of discussion has arisen as to time and manner of application in order to secure the greatest efficiency.

In order to spray efficiently, a knowledge of the life history and habits of the insect is necessary. This knowledge was obtained by consulting the work of entomologists in this and other states, and by observations made as follows:

In the early spring, larvæ were collected from near-by orchards and from storage houses in Lincoln, placed in cotton stoppered test tubes and kept at a temperature equal to that of their natural habitat in the orchard. The tubes were examined every second day and notes taken on the duration of pupal stage, dates of emerging of moths, etc.

Six sprayed and six unsprayed trees were banded with burlap in such a way that the larvæ, either ascending or descending, would be trapped. These larvæ were collected and treated as stated above. In addition, careful notes were taken in the orchard on dates of appearance of moths, larvæ, and pupæ. Two mature trees were enclosed with window screening; and the moths collected were released inside, where they could be carefully studied and the larvæ collected so that reliable data could be obtained from which to determine the proper dates of application.



Fig. 2—Cage in which codling moths were studied

EXPERIMENTS IN 1913

In the spring of 1913, 213 larvæ were collected.¹ The first moth emerged on May 20, and the emergence reached its highest point June 5. The last moth emerged June 8. No doubt moths emerged in the orchard later than this. The first larva was found June 2. June 20 the larvæ appeared most numerous. The first pupa was found on June 24, and pupation reached its highest point on July 15. On July 10 the second-brood moths began to emerge and on July 25 the emergence had reached its highest point. On July 19 the first of the second-brood larvæ were found. The larvæ of this brood continued to emerge until frost, but diminished rapidly in numbers after August 25.

It was planned to apply the petal-fall spray at Lincoln May 6 to 10, or before the calyx cup of the first blossom to open began to close. Usually only one or two blossoms out of a cluster set fruit, and, as a rule, these are the buds which open first. Unless, because of adverse conditions, these first blossoms fail to become pollinated, they will be the first to close. Therefore, they are the ones which must be protected. The next spray was planned for May 25 to May 31, or just after the first-brood moths began to emerge, in order to be thru spraying just before the eggs began to hatch. The second-brood spray was planned for July 15 to 20, or just after the second-brood moths began to emerge. For the orchards south of Lincoln it was planned to apply each spray a few days earlier, and for those north, a few days later. However, it was found necessary to vary the dates somewhat.

The following diagram will indicate the comparative dates in the development of the codling moth at Lincoln, and the dates of spraying.

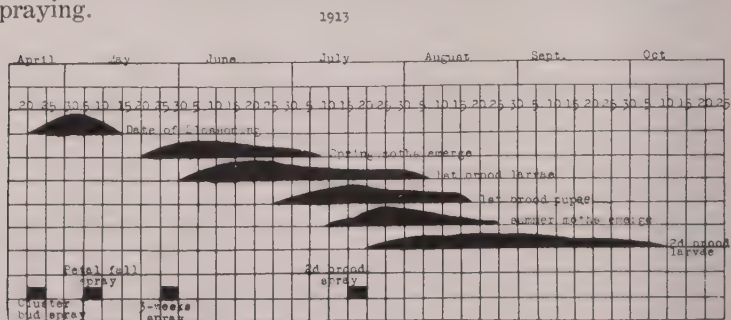


Fig. 3 - Shows blooming period of apples, rate of development of codling moth, and dates when spraying was most effective for both codling moth and scab in 1913

¹97 of the larvæ perished.

The weather conditions were not quite normal in 1913. There was a great deal of rain very early in the season, but after the middle of June very little rain fell at Wymore, Brownville, or Lincoln. Conditions were better at Florence, but even there the rainfall was below normal. The hot, dry weather during the latter part of the season caused a heavy dropping of fruit, even where there was no injury.

In every case lime sulphur was used in combination with arsenate of lead, altho it does not appear in the schedules for codling moth. Also, in all cases 45° angle nozzles were used.

'TABLE 1—Wymore spray schedule

Date Spray	April 21 Cluster-bud	May 5 Petal-fall	May 22 2-weeks	July 2 Second-brood
Plat 1.....	Pb-2-50	Pb 2 50	Pb 2 50	Pb 2-50

Codling moth injury on windfalls and picked fruit

Varieties	Plat	Total fruit	Codling moth	Per cent
Ben Davis	{ 1 check	10,472	1,148	10.96
Winesap		2,203	1,080	49.02
Jonathan				

At Wymore (table 1) during this season, a double acting hand pump similar to fig. 19 with two medium mist nozzles was used. At the petal-fall spray a pressure of 160 pounds was maintained. Considering the percentage of codling moth in the check plat as 100 per cent, this schedule was approximately 78 per cent efficient. The fact that 22 per cent of the "worms" found in the apples entered at the calyx indicates that the poison was not forced into all of them. This orchard had not been thoroly sprayed prior to this time.

TABLE 2—Nemaha spray schedule

Date Spray	April 23 Cluster-bud	May 7 Petal-fall	May 30 3-weeks	July 3 Second-brood	July 25 Third-brood
Plat 1.....	Pb 2-50	Pb 2-50	Pb 2-50	Pb-2 50	
2.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis	1	2,180	218	10.00
Winesap	1	2,941	286	9.72
Jonathan	1	2,751	246	8.94
	Total	7,872	750	9.53
Ben Davis	2	1,834	64	3.49
Winesap	2	1,887	58	3.07
Jonathan	2	2,751	95	3.45
	Total	6,472	217	3.35

Unfortunately the "check" trees were given the petal-fall application and are therefore not recorded.

At Nemaha (table 2), a power spray of 12-gallons-to-the-minute capacity, similar to fig. 23, was used. The petal-fall spray was applied with Bordeaux nozzles under a pressure of 250 pounds. All other applications were made with mist nozzles. It is unfortunate that we have no check with which to compare the sprayed plats. It is interesting to note that a spray applied 22 days after the regular second-brood spray reduced worm injury 6.18 per cent. Nearly 50 per cent of the larvæ entered at the calyx. The trees here were so tall that it was difficult to reach the tops, and no doubt a larger percentage of first-brood larvæ escaped than would have been the case with smaller trees. This orchard had never been sprayed before.

TABLE 3—*Brownville spray schedule*

Date Spray		May 8 Petal-fall	May 31 3-weeks	
Plat 1		Pb-2-50	Pb 2 50	
2				

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis {	1	20,273	3,368	16.61
Mo. Pippin {	check	1,804	1,298	71.95

At Brownville (table 3), a barrel pump similar to fig. 18 with one mist nozzle was used for the calyx application. For the next application a one-man power sprayer of 3- to 4-gallons-per-minute

capacity was used. Here the efficiency for the two sprays was 77 per cent. Slightly more than 50 per cent of the worms entered at the calyx. This orchard had never been sprayed before.

It was planned to apply four sprays, but the machinery was not received in time for the first spray and water could not be obtained for the second-brood spray.

TABLE 4—*Florence spray schedule*

Date Spray	April 24 Cluster-bud	May 10 Petal-fall	June 3 3-weeks	July 16 Second-brood
1	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis	1 check	1,598	203	12.70
Winesap		3,285	2,286	69.60
Jonathan				

At Florence (table 4), a power sprayer of 10-gallons-to-the-minute capacity, similar to fig. 21, was used. The petal-fall spray was applied with Bordeaux nozzles at 225 pounds pressure. The efficiency of the schedule was 82 per cent. Slightly more than 43 per cent of the larvæ entered at the calyx. This orchard had never been sprayed before.

TABLE 5—*Lincoln spray schedule*

Date Spray	April 25 Cluster-bud	May 9 Petal-fall	June 2 3-weeks	July 15 Second-brood
Plat 1.....	Pb-3-50	Pb-3-50	Pb-3-50	Pb-3-50
2.....	Pb-3-50	Pb-3-50	Pb-3-50	Pb-3-50
3.....	Pb-3-50	Pb-3-50	Pb-3-50	Pb-3-50

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis	1 2 3 check	2,549	273	10.71
Winesap		2,234	396	17.73
Jonathan		3,762	501	13.32
		3,530	1,172	33.20

At Lincoln the same capacity machine was used as at Nemaha. Mist nozzles were used for all applications. At the petal-fall spray a pressure of 250 pounds was maintained. The efficiency of the schedule for plat 1 was 68 per cent; for plat 2, 47 per cent; and for plat 3, slightly below 60 per cent. Forty per cent of the larvæ found in the fruit entered at the calyx.

The results of the first year's work on codling moth control indicate either (1) that the spraying was not thoroly done, (2) that the applications were not made at the right time, or (3) that the poison was not used in sufficient quantities.

There is no doubt that the spraying was done at the right time at Lincoln, where the closest observations of codling moth development were made.

That the poison was used in sufficient quantities is shown by the fact that the 2-50 formula, which was used in most cases, was as efficient as the 3-50 formula, as indicated in table 5. This will be discussed more fully under "a comparison of different brands of arsenate of lead."

It is evident that the spraying was not thoro. The fact that approximately 41 per cent of the larvæ found in the fruit entered at the calyx would indicate that the poison was not present in sufficient quantity, from not having been forced into the calyx cups. This lack of thoroness was for the most part unavoidable. The trees at Nemaha were so high that it was impossible to spray the tops from above. At Florence and Lincoln the wind was so strong that it was impossible to spray from but one direction. At Brownville and Wymore the pressure maintained during the petal-fall spray was irregular, hand power pumps being used at these places.

EXPERIMENTS IN 1914

In the spring of 1914, 198 larvæ were obtained. The moths began emerging May 25. Emergence reached its height about June 15. The first larvæ were found June 5. The first pupæ were taken June 25. By July 10 the summer brood of moths was beginning to emerge. Within ten days the second-brood larvæ were at work. The first of August, third-brood pupæ were found. Moths emerged about August 15, and the third-brood larvæ were at work by August 20.

Observations in the field indicated that larvæ were hatching in large numbers almost continually from the first of June until frost.

The weather conditions for 1914 were abnormal from the first. Little rain fell thruout the season and fruit dropped badly. Orchard insects multiplied very rapidly during the extremely hot, dry weather. This was especially true of the codling moth. This season practically a full third brood of larvæ appeared.

The following diagram indicates the comparative dates of codling moth development and spraying at Lincoln.

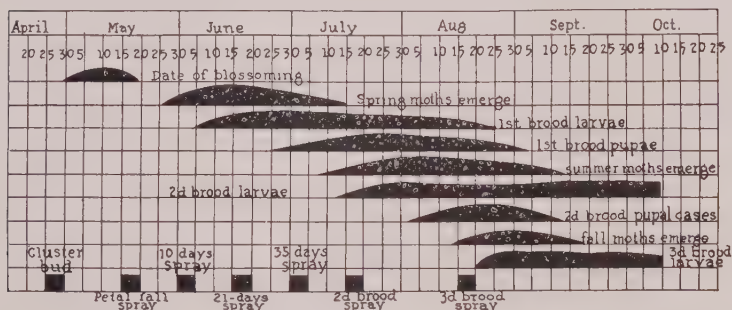


Fig. 4—Shows blooming period of apples, rate of development of codling moth, and dates when spraying was most effective for both codling moth and scab in 1914

The same general plan was followed as in 1913 except that an attempt was made to control the moths by spraying more thoroly at the petal-fall application and shifting the date of the third application.

TABLE 6—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 15 Petal-fall	May 25 10-days	June 12 25-days	June 22 35-days	July 14 2d-brood
Plat 1.....	Pb 2 50	Pb-2-50	.....	.....	Pb-2-50	Pb-2-50
2.....	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50
3.....	Pb-2-50	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis Mo. Pippin	1	12,133	3,426	28.23
	2	14,172	3,592	25.35
	3	10,339	3,877	37.50
	check	14,845	11,024	74.26

At Beatrice (table 6), a new power sprayer of 8-gallons-to-the-minute capacity was used. Bordeaux nozzles were used for the petal-fall spray and a pressure of 225 to 250 pounds maintained. The schedule for plat 2, with an efficiency of 66 per cent, gave the best results, followed by plats 1 and 3, respectively. Over 40 per

cent of the larvæ entered at the calyx in spite of the careful spraying with Bordeaux nozzles. This was due in part to the rapid closing of the calyces during the extremely hot weather that prevailed, and in part to delay caused by an accident to the machine which made the application later than it should have been.

TABLE 7—*Lincoln spray schedule*

Date Spray	April 25 Cluster-bud	May 15 Petal-fall	June 15 25-days	June 30 35-days	July 14 2d-brood	Aug. 14 3d-brood
Plat 1.....	Pb-2-50	Pb-2-50	Pb-2-50	.....	.....	.....
2.....	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50	.....
3.....	.....	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....
4.....	Pb 2 50	Pb 2 50	Pb-2-50	.....	.....	Pb-2-50
5.....	Pb-2-50	Pb-2-50	Pb-2-50	.....	Pb 2-50	Pb-2-50
6.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis Jonathan	1	22,681	17,573	77.48
	2	21,086	14,587	69.17
	3	21,774	13,122	60.27
	4	29,688	17,035	57.38
	5	24,140	5,819	24.10
	6	19,233	3,453	17.95
	check	14,186	13,322	93.91

At Lincoln (table 7), a power machine of 10-gallons-to-the-minute capacity was used. Mist nozzles were used for the petal-fall spray and a pressure of 200 to 225 pounds was maintained. The efficiency of the spray schedule for plat 6 was 81 per cent and for plat 5, 75 per cent. The schedules for all the remaining plats were below 50 per cent, that of plat 1 being only 18 per cent.

A little more than 30 per cent of the larvæ in the fruit entered at the calyx. The fact that a high wind was blowing at the time of the petal-fall spray, making it impossible to spray except from one direction, may account for the high percentage of calyx worms. However, by far the greater percentage of injury was from worms entering the sides of the apples during August and September. That the greater part of the damage was done by late "worms" is shown by the high percentage controlled by the last three sprays.

The results of the year's work again indicate that the petal-fall spray was not thoro enough. The poor results of this spray were doubtless due to the extremely rapid reproduction of the moths which escaped poisoning at that time. Considering the number of "worms" which entered the fruit at the calyx and the number which entered the fruit thru this point on unsprayed trees, the efficiency of the calyx application was slightly above 55 per cent.

Considering the number of first-brood larvæ trapped on the sprayed and on the unsprayed trees, the efficiency of the calyx spray was much higher. The average number of moths captured under bands on sprayed trees was 12.6 and on the unsprayed trees was 151. This would make the efficiency of the calyx and the next application combined, 91.7 per cent.

There is no doubt some error in any methods of calculating the efficiency of a single spray, unless applied alone. Many of the larvæ upon entering a calyx well filled with poison, especially where it is combined with lime sulphur or Bordeaux, will no doubt be repelled by the covering and seek other points of entrance. Again the calyces of many varieties of apples, such as Grimes and Ben Davis, expand considerably as the fruit grows, which will, to some extent, diminish the protection by exposing new, unpoisoned surfaces. Hence it is likely that some "worms" which, except for the poison, would have entered the fruit at the calyx, enter some place else, while others find a safe entrance at the calyx in spite of the poison.

EXPERIMENTS IN 1915

The spring and summer of 1915 and the following fall were too cool for the codling moth to reproduce rapidly, consequently only two broods appeared. Only 176 larvæ were collected for early observations and of these but 63 produced moths. The moths began emerging the first of June. Larvæ began appearing after June 15. No pupæ were found until about July 20. Second-brood moths began emerging from these about August 10. The second-brood larvæ commenced work about August 25. By this time in 1914 the third-brood larvæ were appearing.

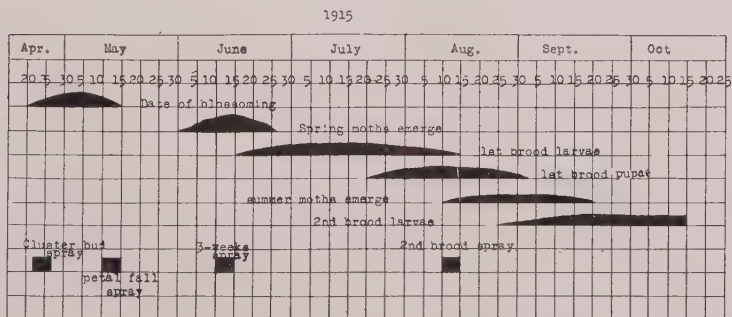


Fig. 5—Shows blooming period of apples, rate of development of codling moth, and dates when spraying was most effective for both codling moth and scab in 1915

The weather conditions during the season of 1915 were slightly abnormal in that the precipitation was more than usual and ex-

tended well into the fall. The temperature during the greater part of the season was slightly lower than normal. Because of these conditions the codling moth did not multiply as rapidly as during the two preceding seasons. The broods were more definitely defined, and the second brood was considerably later in appearing than in 1913 or 1914.

The same general plan was followed as in 1913 and 1914. A strenuous effort was made to fill all the calyx cups thoroly, and it was planned to apply the third spray on different plats 7, 14, 21, and 35 days respectively after the falling of the petals.

TABLE 8—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 24 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1...	Pb 1.5-50	Pb-1.5-50	¹ Pb 1.5-50			Pb-1.5-50
2...	Pb-1.5-50	Pb-1.5-50		¹ Pb-1.5-50		Pb-1.5-50
3...	Pb-1.5-50	Pb 1.5-50	Pb-1.5-50		¹ Pb 1.5-50	Pb-1.5-50
4...	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50		Pb-1.5-50	

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Ben Davis	1	1,602	178	11.11
	2	4,711	111	2.36
	3	1,733	48	2.77
	4	1,710	119	6.96
	check	6,853	2,224	32.45
Mo. Pippin	1	1,510	85	5.63
	2	2,631	111	4.22
	3	2,037	29	1.42
	4	914	45	4.92
	check	5,966	1,649	27.64
Ben Davis Mo. Pippin	1	3,112	263	8.45
	2	7,342	222	3.02
	3	3,770	77	2.04
	4	2,624	164	6.25
	check	12,819	3,873	30.21

At Beatrice (table 8), the same machinery was used as in 1914. Bordeaux nozzles were used for the petal-fall spray on all but one plat, and a pressure of 225 to 250 pounds was maintained. Coarse mist nozzles at a pressure of 250 pounds were used on one plat. The efficiency of the schedules was: No. 3, 93.3 per cent; No. 2,

¹Arsenate of lead was combined with Bordeaux.

90 per cent; No. 4, 80 per cent; and No. 1, 73 per cent. It is impossible to account satisfactorily for the poor results in plat No. 1, except that this plat was the south row of the orchard and being on the outside was reinfested from other sources. Less than 2 per cent of the larvæ entered the fruit at the calyx. Where coarse mist nozzles were used at the petal-fall spray, less than one per cent of calyx wormy apples were found.

TABLE 9—*Lincoln spray schedule*

Date Spray	April 26 Cluster-bud	May 10 Petal-fall	May 18 7-days	June 1 14-days	June 8 21-days	June 24 35-days	Aug. 11 2d-brood
Plat 1.		Pb-1.5-50		Pb-1.5 50			Pb-1.5-50
2.	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50				Pb-1.5-50
3.	Pb-1.5-50	Pb-1.5-50		Pb-1.5-50			Pb-1.5-50
4.	Pb-1.5-50	Pb-1.5-50			Pb-1.5-50		Pb-1.5-50
5.	Pb-1.5-50	Pb-1.5-50		Pb-1.5-50		Pb-1.5-50	Pb-1.5-50
6.	Pb-1.5-50	Pb-1.5-50		Pb-1.5-50			

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Jonathan	1	6,744	154	2.28
	2	4,919	162	3.29
	3	3,037	15	.49
	4	6,980	95	1.36
	5	4,463	60	1.34
	6	5,007	378	7.55
	check	6,410	1,184	18.47
Winesap	1	3,692	79	2.14
	2	2,582	93	3.60
	3	2,057	107	5.20
	4	1,385	64	4.62
	5	2,274	40	1.76
	6			
	check	2,343	851	36.32
Ben Davis	1	2,057	30	1.46
	2	2,088	44	2.11
	3	2,867	24	.84
	4	1,867	14	.75
	5	2,486	42	1.69
	6	2,265	121	5.34
	check	2,880	1,715	59.55
Jonathan Winesap Ben Davis	1	12,493	263	2.105
	2	9,589	309	3.22
	3	7,961	146	1.83
	4	10,232	173	1.69
	5	9,223	142	1.54
	6 ¹	7,272	499	6.86
	check	11,633	3,750	32.24

¹No Winesap.

At Lincoln (table 9), the same machinery was used as the year before. Bordeaux nozzles were used for the petal-fall spray on all but one plat. The pressure was not as constant as it should have been, varying from 175 to 250 pounds. No tower was used, but one man sprayed from the top of the engine house on the rear of the machine. The efficiency of this schedule was: No. 5, 95 per cent; No. 4, 94.5 per cent; No. 3, 94 per cent; No. 1, 93.5 per cent; No. 2, 90 per cent; and No. 6, 79 per cent. Slightly more than 10 per cent of the larvæ entered at the calyx. Certainly the schedule would have been more efficient had the pressure been more constant, and had the principal part of the spraying been done from a tower.

TABLE 10—*South Omaha spray schedule*

Date Spray	April 27 Cluster-bud	May 11 Petal-fall	May 22 7-days	May 29 14-days	June 11 21-days	June 25 35-days	Aug. 13 2d-brood
Plat 1..	Pb-2-50	Pb-2-50	Pb-2-50	.....	.....	.....	Pb-2-50
2..	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....	.....	Pb-2-50
3..	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50	.....	Pb-2-50
4..	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50	Pb-2-50
5..	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50	.....

Codling moth injury on windfalls and picked fruit

Variety	Plat	Total fruit	Codling moth	Per cent
Jonathan	1	3,130	8	.256
	2	4,703	13	.276
	3	4,062	9	.222
	4	5,094	42	.824
	5	2,883	76	2.636
	check	6,353	603	9.492
	1	4,189	51	1.2175
Ben Davis	1	680	11	1.6177
	2	3,195	35	1.095
	3	2,482	5	.2014
	4	1,243	9	.7241
	5	1,141	36	3.155
	check	1,333	108	8.102
Jonathan Ben Davis	1	3,810	19	.499
	2	7,898	48	.607
	3	6,544	14	.214
	4	6,337	51	.805
	5	4,024	112	2.783
	check	7,686	711	9.25

¹Given second brood spray only.

At South Omaha (table 10), a power sprayer of 10- to 12-gallons-to-the-minute capacity was used. At the petal-fall spray, coarse mist nozzles were used with a pressure of 225 to 250 pounds. Two men sprayed from the tower and one from the ground.

The efficiency of the schedule was, for plat No. 3, 97.7 per cent; No. 1, 94.7 per cent; No. 2, 93.5 per cent; No. 4, 91.3 per cent; and No. 5, 70 per cent. Approximately 3 per cent of the "worms" found in the fruit entered at the calyx end.

The low percentage of wormy fruit in the check trees was due to the fact that Mr. Beavers has been spraying thoroly for several seasons past. Two trees were selected in an orchard which has never been sprayed, one-half mile from Mr. Beavers' orchard, and the fruit examined. The Ben Davis apples were 60 per cent wormy and the Jonathan 49 per cent wormy.

TABLE 11—*Effects of various commercial arsenates of lead*

	Treatment	Applica- tions	Total number picked apples	Codling moth	Per cent	Effi- ciency
1913						
1	2-50 Herman's calcite.....	1-2-3-4	1,365	138	10.11	69
2	1½-50 Ansbacher powdered arsenate of lead.....	1-2-3-4	1,766	190	10.76	68
3	2½-50 Ansbacher powdered arsenate of lead.....	1-2-3-4	4,674	467	9.99	70
4	2-50 DeVoe & Reynolds paste arsenate of lead....	1-2-3-4	3,741	386	10.31	69
5	2-50 Sherwin-Williams paste arsenate of lead....	1-2-3-4	2,976	352	11.83	67
6	2-50 Grasselli paste arsenate of lead.....	1-2-3-4	5,416	676	12.46	63
7	2-50 Rex paste arsenate of lead.....	1-2-3-4	2,761	331	11.99	64
8	3-50 Rex paste arsenate of lead.....	1-2-3-4	1,896	231	12.18	63
9	2-50 Hemingway's paste arsenate of lead.....	1-2-3-4	1,241	143	11.52	65
10	Check.....	no spray	3,530	1,172	33.2	.....
1915						
1	1½-50 Sherwin-Williams powdered arsenate of lead.	1-2-3-4	12,783	381	2.12	93.5
2	1½-50 Corona powdered arsenate of lead.....	1-2-3-4	6,051	187	3.09	90.5
3	2½-50 Rex paste arsenate of lead.....	1-2-3-4	10,774	132	1.22	96
4	Check.....	no spray	11,633	3,750	32.24	.....

A careful perusal of table 11 indicates that 2 pounds of arsenate of lead paste or $1\frac{1}{4}$ pounds of arsenate of lead powder is sufficient. Much complaint has been registered against certain brands of arsenate of lead. The above results show them to be of about equal value, in proportion to the amount of arsenic contained in combination.

The results of the last year's work (1915) indicate that conclusions drawn from the two preceding years' work were in the main correct, i. e., that the efficiency of a spray schedule for the control of codling moth depends very largely upon the thoroness of the petal-fall application. However, this application is not in itself sufficient, even though every calyx receive a good dose of poison. Approximately 20 per cent of the first-brood "worms" normally enter the fruit at various points, other than the calyx, on unsprayed trees. The spray materials lodged in the calyces certainly will cause some of the larvæ which would otherwise enter the calyx to seek other places of entrance, so that the percentage of the larvæ which enter the fruit from other points must be appreciably increased. This is borne out by the fact that even with the most thoro calyx spraying in 1915, 20 to 40 per cent of the worms were controlled by the late applications. Comparing the number of calyx-wormy apples found on the sprayed and the unsprayed trees, the efficiency of the calyx spray was 97.7 per cent at Beatrice, 96.5 per cent at South Omaha, and 89 per cent at Lincoln.

After carefully comparing all data for the three years' work, it is apparent that in any orchard, unless very thoro spraying has been practiced in the past, it will be necessary to make three applications during a normal season and four or possibly five during an excessively hot, dry season like that of 1914. Even in well-sprayed orchards the omission of one of these sprays for a single season is inadvisable. Two or three per cent of a crop saved will pay for considerable spraying.

It is very evident that the petal-fall application is by far the most important. The best results were obtained when the spray was applied as a coarse mist (not necessarily with Bordeaux nozzles) under considerable pressure and directed squarely against the open calyx. For this reason the main part of the spraying for this application should be done from the tower. If, on account of high winds or other unfavorable conditions, the application has not been thoro, it will pay to go over the orchard again immediately.

The highest efficiency from the next spray following the calyx application was secured when it was applied just before the young

larvæ began to hatch.¹ At this time the calyces point down and the spray should be directed against the fruit and foliage from all angles to insure complete covering. Normally this spray should be applied 14 to 21 days after the petals fall.

Next to the calyx-spray the second-brood application is the most important. It should be applied just as the second-brood larvæ begin to hatch, and in the same manner as for the preceding spray.

Two pounds of lead to 50 gallons of spray was found to be as efficient as more. There is some indication that the cluster-bud spray in some of the schedules had some effect in controlling codling moth injury, but there is not enough evidence of this to warrant making any statement to that effect.

THE PLUM CURCULIO

In the past the plum curculio has not been considered as a particularly serious pest in Nebraska, except on stone fruits. However, from certain sections of the state so much damage has been reported of late years that it was deemed expedient to attempt to evolve some means of controlling the insect. Accordingly, a study was made of the effects which sprays, applied for the control of codling moth, would have on the plum curculio.

The primary injury done by the curculio consists of small holes made in the apples in feeding and for depositing eggs. However, this is only a small part of the injury. These punctures cause the fruit to become ill-shaped and knotty, and admit fungi.

The beetles pass the winter as adults under trash and rubbish, and emerge and begin feeding on the new leaves before the blossoms open. As soon as the fruit sets they begin feeding on it and depositing their eggs.

There seems to be a division of opinion among workers along this line as to whether any feeding is done by the curculio before

¹The only way to know definitely when this and the second-brood spray should be applied is to observe the development of the moths and larvæ each season. The importance of this may be readily seen by comparing the charts for the different years and noting the different dates of hatching of the larvæ.

There is a correlation between weather conditions and the development of the codling moth. Not only are all of the periods of the life cycle of the insect shorter in midsummer when the days are long and hot than they are earlier in the spring, but they are shorter throughout and the insects develop much more rapidly during hot, dry seasons like 1914 than in cool, moist weather of seasons like 1915. Temperature seems to be the determining factor. During the time when observations were being taken, the larvæ were always found more lively on warm than on cool days. In fact on one occasion when the temperature suddenly dropped to 40 degrees the larvæ remained almost entirely inactive. It was also noted that the emergence of the moths was closely correlated with the temperature. The moths would emerge in large numbers during bright, warm weather; and during a drop in temperature would cease emerging altogether, to begin again as the temperature rose.

By collecting larvæ early in the spring, keeping them confined until they pupate and emerge as moths, then repeating the operation for the second brood and the third brood, if necessary, and by noting weather conditions, every orchardist should be able to spray so that he may secure the highest efficiency from the materials used. The best materials will give at best poor results if used at the wrong time.

the blossoms open (Stedman, 1904, Crandall, 1905, and Brooks, 1910). The beetles were found at work in Nebraska before this time, and it was determined to try a poison spray applied before the regular petal-fall application.

EXPERIMENTS IN 1913

Notes on curculio injury were taken from the same trees and at the same time that the codling moth data were taken. For methods of spraying, etc., see discussion on control of codling moth. In the tables, larvæ are designated as "worms," and feeding punctures, egg punctures, etc., as "stings."

TABLE 12—*Wymore spray schedule*

Date Spray	April 21 Cluster-bud	May 5 Petal-fall	May 22 3-weeks	July 2 Second-brood
Plat 1	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio			
			Worms	Per cent	Stings	Per cent
Ben Davis	{ 1 check	10,472	24	.23	51	.51
Missouri Pippin		2,203	13	.59	214	9.71

At Wymore the efficiency of the schedule was 63 per cent in the control of larvæ and 99.48 per cent in the control of skin punctures. This would indicate that the spray acted as a repellent in addition to poisoning the insects. The fact that the orchard was under clean cultivation would also account, in part, for the comparatively low percentage of stings.

TABLE 13—*Brownville spray schedule*

Date Spray		May 8 Petal-fall	May 31 3-weeks	
Plat 1.....	.....	Pb-2-50	Pb-2-50	.....

(1904) Stedman, J. M. The sting in the apple. Missouri Sta. Bul. No. 64.

(1905) Crandall, Chas. S. The curculio and the apple. Illinois Sta. Bul. No. 98.

(1910) Brooks, Fred E. Three snout beetles that attack apples. West Virginia Sta. Bul. No. 126.

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio			
			Worms	Per cent	Stings	Per cent
Ben Davis	{ 1 check	20,273	532	2.62	1,091	5.38
Missouri Pippin		1,804	102	5.10	119	6.59

At Brownville (table 13), the efficiency of the schedule was 54 per cent in controlling the larvæ, which was nearly as much as for the 4-spray schedule at Wymore, but in the control of skin punctures the efficiency was only 19 per cent.

TABLE 14—*Nemaha spray schedule*

Date Spray	April 23 Cluster-bud	May 7 Petal-fall	May 30 3-weeks	July 3 Second-brood
Plat 1.....		Pb-2-50	Pb-2-50	Pb-2-50
2.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Curculio injury on windfalls and picked fruit

	Plat	Total fruit	Curculio	Per cent
Ben Davis	1	2,180	59	2.71
Winesap	1	2,941	74	2.52
Jonathan	1	2,751	76	2.76
	Total	7,872	209	2.65
Ben Davis	2	1,834	5	.27
Winesap	2	1,887	5	.26
Jonathan	2	2,751	8	.29
	Total	6,472	18	.28

At Nemaha (table 14), apples containing larvæ and those injured by punctures were grouped together under one head. There were few larvæ compared to punctures. No checks were left here; hence it is impossible to compute the efficiency of the schedule. However, the results indicate, provided the infestation was comparable to that at Brownville (table 13), that a large portion of the injury may be controlled by the first spray.

TABLE 15—*Florence spray schedule*

Date Spray	April 24 Cluster-bud	May 10 Petal-fall	June 3 3-weeks	July 16 Second-brood
Plat 1.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio	Per cent
Ben Davis	1 check	2,154	3	.14
Winesap		3,285	285	8.68
Jonathan				

At Florence (table 15), as in table 14, both larvæ and punctures were grouped together. The efficiency for the schedule for both combined was 99.86. The results of the year's work clearly indicate that the damage caused by the plum curculio can be greatly reduced by spraying.

EXPERIMENTS IN 1914

During this season both larvæ and punctures are grouped under the same heading. The damage done by curculio this year was very light.

TABLE 16—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 15 Petal-fall	May 25 10-days	June 12 25-days	June 22 35-days	July 14 2d-brood codling moth
Plat 1...	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50	Pb-2-50
2...	Pb-2-50	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50
3...	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50	.....	Pb-2-50
4...	.....	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio	Per cent
Mixed	1	8,573	3	.035
	2	9,613	0	.0
	3	11,242	0	.0
	4	7,251	119	1.64
	check	14,845	393	2.647

For schedules Nos. 1, 2, and 3 (table 16) the efficiency was practically 100 per cent. For schedule No. 4 the efficiency was 48 per cent. This difference, when considering the amount of infestation, could easily be due to individual variation.

TABLE 17—*Wymore spray schedule*

Date Spray	April 23 Cluster-bud	May 14 Petal-fall	June 10 3-weeks	July 12 Second-brood
Plat 1.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50
<i>Curculio injury on windfalls and picked fruit</i>				
Variety	Plat	Total fruit	Curculio	Per cent
Ben Davis {	1	5,603	2	.03
Mo. Pippin {	check	4,063	4	.09

At Wymore (table 17), there was practically no damage by curculio either on the sprayed plats or on the checks. Probably the fact that the orchard was thoroly sprayed and cultivated the year before would account in part for the light infestation.

TABLE 18—*Seward spray schedule*

Date Spray	April 30 Cluster-bud	May 20 Petal-fall	June 18 3-weeks	
Plat 1.....	Pb-2-50	Pb-2-50	Pb-2-50	
<i>Curculio injury on windfalls and picked fruit</i>				
Variety	Plat	Total fruit	Curculio	Per cent
Ben Davis { Winesap {	1 check	4,180 1,982	9 41	.21 2.07

The efficiency of the schedule at Seward (table 18) was approximately 90 per cent. Here, as in the other orchards, the infestation was so light that there was very little damage even on the check trees.

TABLE 19—*Lincoln spray schedule*

Date Spray	April 25 Cluster-bud	May 15 Petal-fall	June 15 3-weeks	July 14 Second-brood codling moth
Plat 1.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50
2.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50
3.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50
4.....	Pb-2-50	Pb-2-50	Pb-2-50	Pb-2-50

Curculio injury on windfalls and picked fruit

	Total fruit	Curculio	Per cent
Plat 1.....	22,681	0	.0
2.....	21,086	19	.09
3.....	21,774	348	1.64
4.....	23,569	0	.0
Check	14,186	361	2.54

The efficiency of schedules Nos. 1, 2 and 4 (table 19) was approximately 100 per cent and that of schedule No. 3, 37 per cent.

The curculio infestation in all of the orchards under observation was so light that no reliable conclusion can be drawn. However the importance of the cluster-bud application as shown in tables 16 and 19 must be more than a coincidence.

EXPERIMENTS IN 1915

In 1915, the work was continued as in the preceding years, but in the data the larvæ and skin punctures were recorded separately.

TABLE 20—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 24 14-days	August 10 Second-brood codling moth
Plat 1.....	¹ Pb-1.5-50	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50
2.....	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50
3.....	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50	¹ Pb-1.5-50
4.....	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50

¹Arsenate of lead was combined with Bordeaux mixture instead of lime sulphur.

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio worms	Per cent	Curculio stings	Per cent
Ben Davis	1	3,156	0	.0	103	3.26
	2	3,112	0	.0	132	4.21
	3	3,289	6	.18	147	4.46
	4	2,794	1	.03	92	3.26
	check	12,819	162	1.26	1,016	7.93

The results in table 20 would indicate that there is very little if any benefit derived from the second-brood spray for codling moth, so far as curculio injury is concerned.

TABLE 21—*Omaha spray schedule*

Date Spray	April 27 Cluster-bud	May 11 Petal-fall	May 22 7-days	May 29 14-days	June 11 21-days	Aug. 13 2d-brood
Plat 1	Pb-2-50	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50
2	Pb-2-50	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50
3 . . . . .	.....	Pb-2-50	.....	Pb-2-50	.....	Pb-2-50
4	Pb-2-50	Pb-2-50	.....	.....	Pb-2-50	Pb-2-50

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio worms	Per cent	Curculio sting	Per cent
Jonathan	1	2,644	0	.0	10	.38
	2	4,651	0	.0	36	.77
	3	4,069	11	.2704	43	1.06
	4	3,912	0	.0	20	.51
	check	6,353	28	.4407	207	3.26
Ben Davis	1	1,107	0	.0	7	.63
	2	1,875	0	.0	24	1.28
	3	2,064	8	.3876	50	2.42
	4	1,241	0	.0	8	.64
	check	1,333	39	2.92	114	8.55
Jonathan Ben Davis	1	3,751	0	.0	17	.45
	2	6,526	0	.0	60	.99
	3	6,133	19	.31	93	1.52
	4	5,153	0	.0	28	.54
	check	7,686	67	.87	321	4.18

The results shown in table 21 indicate that the regular sprays intended for the control of the codling moth, plus an earlier spray, will control practically all of the curculio larvæ and approximately

80 per cent of the damage from skin punctures. This table shows the efficiency of the first spray alone to be nearly 50 per cent. The light infestation in this orchard is due largely to the fact that clean culture is practiced and all windfalls removed.

TABLE 22—*Lincoln spray schedule*

Date Spray	April 26 Cluster-bud	May 10 Petal-fall	May 18 7-days	June 1 14-days	June 8 21-days	June 24 35-days	Aug. 11 2d-brood
Plat 1..		Pb-1.5-50		Pb-1.5-50			Pb-1.5-50
2..	Pb-1.5-50	Pb-1.5-50	Pb-1.5-50				Pb-1.5-50
3..	Pb-1.5-50	Pb-1.5-50		Pb-1.5-50			Pb-1.5-50
4..	Pb-1.5-50	Pb-1.5-50			Pb-1.5-50		Pb-1.5-50
5..	Pb-1.5-50	Pb 1.5-50				Pb-1.5-50	Pb-1.5-50

Curculio injury on windfalls and picked fruit

Variety	Plat	Total fruit	Curculio worms	Per cent	Curculio sting	Per cent
Jonathan.....	1	6,483	147	2.27	274	4.23
	2	5,753	15	.26	111	1.93
	3	3,037	0	.0	15	.49
	4	6,980	0	.0	215	3.08
	5	4,463	2	.045	167	3.74
	check	6,410	177	2.76	917	14.30
Winesap.....	1	2,207	19	.86	63	2.85
	2	2,918	6	.21	102	3.49
	3	2,057	3	.15	33	1.60
	4	1,385	0	.0	52	3.75
	5	2,274	0	.0	79	3.47
	check	2,343	131	5.59	396	16.90
Ben Davis....	1	1,498	18	1.20	145	9.68
	2	2,214	9	.41	41	1.85
	3	2,867	0	.0	93	3.24
	4	1,867	0	.0	38	2.03
	5	2,486	0	.0	53	2.13
	check	2,880	122	4.24	433	15.03
Jonathan Winesap Ben Davis	1	10,188	184	1.81	482	4.73
	2	10,885	30	.27	254	2.33
	3	7,961	3	.038	141	1.77
	4	10,232	0	.0	305	2.98
	5	9,223	2	.022	299	3.24
	check	11,633	430	3.70	1,746	15.01

The evidence presented in table 22 corroborates the statements made in regard to table 21. However, as compared with table 21 it shows a lower general efficiency. This is no doubt due to the

fact that the orchard was allowed to grow up to grass and weeds, and that windfall apples were allowed to remain under the trees. In the early windfalls, many curculio larvæ lived to maturity and thus reinfested the orchard.

Considering all the facts known in regard to the life history of the plum curculio and the facts gathered during the last three years' work, the accumulated evidence shows that by taking advantage of certain habits of the insect, its control is comparatively easy and certain.

(1) The adults hibernate during the winter under trash and rubbish in the orchard.

(2) After a winter of fasting they are very voracious and in the spring commence feeding on the new leaves and buds before the blossoms are open.

(3) The larvæ are unable to live to maturity in the apples when they remain on the tree. Only those larvæ which are in the apples that fall early reach maturity and become beetles.

(4) The larvæ begin entering the ground about the middle of July and continue up to the middle of August or later. The pupæ cases are placed at an average depth of 1 to 2 inches.

Therefore, control measures which suggested themselves and which proved effective are: The removal of trash and rubbish, accompanied by early spring plowing; thoro spraying with arsenate of lead before the blossoms open, followed by the regular codling moth schedule; the removal of early windfalls, which may contain larvæ, from the orchard; and lastly, thoro cultivation of the orchard from the middle of July to the middle of August.

SPRAYING FOR THE CONTROL OF FUNGOUS DISEASES

APPLE SCAB

One of the determining factors in the production of apples in Nebraska is the prevalence of apple scab. This disease has long been considered serious and a great deal of work has been done concerning its life history and methods of control. Notwithstanding the fact that its destructiveness is well known and that reasonably sure methods of control have been published, the disease goes merrily on taking its toll of more than 50 per cent of the fruit of the state. As a matter of fact the loss is often even more than it appears. 1. The young apples drop prematurely, due to the attacks of the fungus upon the flowers and petioles before and during the blossoming period, and on the young fruit later. This was especially noticeable during the seasons of 1913 and 1915. At blossoming time the bloom was as heavy on the check as on the sprayed trees. The set of fruit on the sprayed trees was

much heavier than on the check trees, and the number of apples which dropped prematurely much less. This was also noted by Emerson (1905). 2. The leaves are also attacked. In unsprayed orchards, the foliage is sometimes so severely injured that the fruit never attains salable size, and scarcely any growth is made by the trees. It often takes two or three years of thoro spraying to bring the trees back to normal growth and productiveness. 3. Scab also impairs the keeping qualities of fruit. At harvest time in 1915 several boxes of Winesap, Arkansas, and Ben Davis apples were sorted for exhibition, and for use in fruit judging. A part of each variety came from trees having considerable scabby fruit and a part from trees having no scab. All the fruit was free from visible scab when packed. Some of the fruit was placed in cold storage and some in cellar storage. When the fruit was examined in January, 1916, 10 per cent of the fruit in cold storage was scabby and 68 per cent of the fruit in cellar storage was scabby. The fruit in cold storage was held a few days before being stored and was taken out 2 days before being examined.

Development of scab in storage was also reported from various growers in the State. Several of these reports were followed up, and the fruit was examined and found to have a high percentage of scab. In each case the growers stated that all scab was culled out at packing time. Scab in storage was also noted by Brooks (1908), Morse (1910), Morse and Lewis (1911), Wallace (1913), and Morris (1914).

There is no longer any doubt that the entrance of several serious soft rot fungi is facilitated by scab. Craig and Van Hook (1902), Eustace (1902).

Because of the continued loss by the growers, due to scab, notwithstanding the more or less thoro spraying, further investigation was decided upon to determine to what causes or conditions the lack of control was due.

The general appearance of this disease is so well known that space will not be taken to discuss it here.

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 (1910) Morse, W. J. Notes on Plant Diseases 1908. Maine Agr. Exp. Sta. Bul. 164:4.
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 (1913) Wallace, Errett. Scab Disease of Apples. Cornell Univ. Agr. Exp. Sta. Bul. 335: 574-576.
 (1914) Morris, H. E. A Contribution to Our Knowledge of Apple Scab. Montana Agr. Exp. Sta. Bul. 96:75.
 (1902) Craig, John and Van Hook, J. M. Pink rot, an attendant of apple scab. New York, Cornell Sta. Bul. 207.
 (1902) Eustace, H. J. A destructive apple rot following scab. New York (Geneva) Sta. Bul. 227. *Hypeoknuss* sp. another apple rot following scab. New York (Geneva) Sta. Bul. 255.

Fig. 6 shows the effect of scab on the leaves. Figs. 7 and 8 show the effect on the fruit.



Fig. 6—Shows a leaf affected with apple scab and one free from scab



Fig. 7—A light infection of scab on the fruit

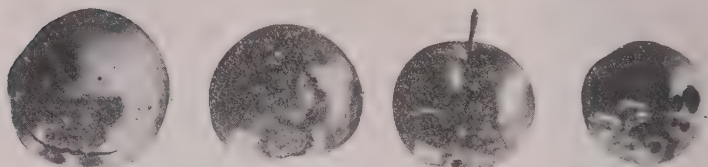


Fig. 8—A severe infection of scab on the fruit

TIME OF INFECTION

Apple scab is a cool weather disease and thrives best under conditions that allow shade and moisture. Under ordinary conditions the period of greatest infection is from the time the leaf buds begin to unfold until two or three weeks after the petals fall. That infection occurs before the blossoms open is shown by the fact that scab was found on a large number of leaves which had been enclosed in Manila paper bags before the blossoms were out. No record of the percentage of infection was secured, because the scab was not noticed until the bags were being exchanged for mosquito netting and by this time many of the clusters had been discarded. Wallace (1913) says "the first infection usually occurs when the blossoms are about to open or as soon thereafter as favorable weather conditions arise."

Where there is an abundance of dead leaves under the trees, the period of infection may be prolonged by the continued development of perithecia in the leaves during a continued period of wet weather.

Regarding the secondary or conidial infection, Wallace says: "The period of incubation may vary from eight to fifteen days; so that after this length of time has elapsed subsequent to the date of the earliest ascospore infection a crop of conidia is produced from which a second, and usually more abundant, infection may appear eight to fifteen days following the first period of weather favorable to infection that occurs after the above crop of spores has ripened. This generation may in turn produce another, and so on throughout the season. However, the various infections do not always occur only in successive jumps at intervals of eight to fifteen days, as the above discussion might lead one to believe. The crop of ascospores are not all matured and do not all discharge at one time. They begin to ripen at about the time indicated above and furnish a constant source of infection for a month or more. Thus the individual infections belonging to the first

generation may be started at several different dates and consequently produce their first crops of conidia at different dates. It is possible also that individual infections occurring at the same time do not all have the same period of incubation. Thus there may be a more or less constant appearance of scab, with the more pronounced jumps at intervals as indicated above. In fact this is what usually occurs.

"The earliest infections usually occur on the lower side of the leaves. This is due to the fact that the lower side is more exposed at that time, while the leaves are unfolding. The later infections occur more abundantly on the upper surfaces, which by that time have assumed a more exposed position."

During the cool, damp season of 1915 there was a great deal of loss due to secondary infection occurring from the latter part of July to the middle of August. To this late infection is attributed a large part of the loss in storage due to scab injury. It is quite possible that infection was taking place later than the middle of August. In fact the evidence indicates that infection was taking place just before the fruit was harvested, and that the storage scab resulted from this late infection, or, that it was caused, after harvesting, by infection from spores on the fruit at that time. The writer is of the opinion that infection occurred before picking, from the fact that some fruit heavily scabbed was stored in the same packages with clean fruit from an orchard free from scab, and when later removed for use, no scab appeared on the fruit from the clean orchard, altho the fruit was stored in the same cellar where so much infection was found.

EXPERIMENTS IN 1913

After reviewing the work already done on the control of apple scab, and carefully going over the situation in Nebraska, it was determined to use fungicides in connection with the regular codling moth and curculio sprays but to leave them out of some of the sprays on certain plats.

Careful observations were made of the time and amount of infection. Records were kept of all scab injury, however small, and of the amount of spray injury for each schedule. No uniform time of infection was found in the different orchards. Florence was the only place where rainfall was normally abundant early in the spring, and at this place the primary infection was heavy. The secondary infection was not heavy any place in the State.

TABLE 23—*Nemaha spray schedule*

Date Spray	April 23 Cluster-bud	May 7 Petal-fall	May 30 3-weeks	July 13 2d-brood	July 25
Plat 1.....	Bx-3-4 50	LS 1.5-50	LS-1.5-50	Bx 3 4 50	.....
2.....	Bx-3-4-50	LS-1.5-50	LS-1.5-50	LS-1-50	Bx-3-4-50
3.....	LS-1.5 50	LS-1.5 50	LS-1.5-50	LS-1-50	.....
4.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	LS-1-50	LS-1-50

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent	Spray injury	Per cent
Ben Davis.....	1	2,180	22	1.01	169	7.752
	2	1,834	10	.54	439	23.93
	3	7,691	46	.60	123	1.60
	4	8,370	95	1.13	335	4.00
Winesap.....	1	2,941	61	2.07	200	6.80
	2	1,887	60	3.18	448	25.86
	3	15,258	373	2.44	446	2.92
	4	16,714	254	1.52	690	4.13
Jonathan.....	1	2,751	32	1.16	254	9.23
	2	2,751	15	.54	259	9.42
	3	11,513	79	.69	187	1.62
	4	12,555	140	1.11	486	3.87
Combined varieties.	1	7,872	115	1.46	623	7.91
	2	6,472	85	1.31	1,146	17.71
	3	34,462	498	1.44	756	2.19
	4	37,639	489	1.30	1,511	4.01

At Nemaha (table 23), no check was left. Therefore, the data are of little value except as a comparison of the value of Bordeaux and lime sulphur, and to show the value of a late spray. The results here indicate that there is practically no difference between the effectiveness of Bordeaux and lime sulphur as a fungicide for scab. They also show that no benefit was derived from the spray following the second-brood codling moth application. However, the summer had been so dry that little effect could be expected. Bordeaux caused more injury at the second-brood application than did lime sulphur and considerably more at the later application. This later application was followed immediately by rainy weather, which may account for the Bordeaux injury. This orchard was neither cultivated nor sprayed before this season.

TABLE 24—*Brownville spray schedule*

Date Spray	Cluster-bud	May 5 Petal-fall	May 30 3-weeks
Plat 1.....	LS-1.5-50	LS-1.5-50
2.....	LS-1.5-50	Bx-3-4-50
3.....	LS-1.5-50	LS-1.5-50
4.....	Bx-3-4-50	Bx-3-4-50

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent	Spray injury	Per cent
Ben Davis and Mis- souri Pippin in equal number, except in plat 3 which con- sists of Arkansas ex- clusively.	1	4,790	53	1.11	49	1.02
	2	4,638	37	.80	15	.32
	3	2,538	17	.67	809	31.87
	4	5,071	58	1.14	2,132	42.04
	check	1,804	312	17.29	.....	.....

At Brownville (table 24), the petal-fall spray, together with the spray following, proved 93.5 per cent efficient on the control of scab where lime sulphur was used for both applications. Where Bordeaux was used for the second spray (plat 2) the efficiency was 95.4 per cent. Where Bordeaux was used for both applications (plat 4) the efficiency showed slightly less than in the case of either plat 1 or 2. The spray injury on this plat was so severe as to bar Bordeaux from use as a fungicide for the petal-fall spray. Plat 3 consisted of the variety Arkansas, alone. On this plat two applications proved to have a slightly higher efficiency in controlling scab than in any of the other plats, but here again the spray injury was very severe. The weather during and following the second application was very hot and dry and the burning was no doubt due to the rapid oxidation of some of the sulphur compounds in the spray. The variety Arkansas seemed to be especially susceptible to this injury. The foliage of all the plats where lime sulphur was used for the second application showed considerable burning, while the foliage on the Bordeaux plats was dark green and free from injury. The foliage was not injured on plat 4. This orchard had never been cultivated or sprayed.

TABLE 25—*Florence spray schedule*

Date Spray	April 24 Cluster-bud	May 10 Petal-fall	June 3 3-weeks	July 16 Second-brood
Plat 1.....	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50
2.....	Bx-3-4-50	LS-1.5-50	Bx-3-4-50	Bx-3-4-50
3.....	Bx-3-4-50	LS-1.5-50	LS-1.5-50	Bx-3-4-50
4.....	Bx-3-4-50	LS-1.5-50	LS-1.5-50	LS-1.5-50
5.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	LS-1.5-50
6.....		LS-1.5-50	LS-1.5-50	LS-1.5-50
7.....	LS-1.5-50		LS-1.5-50	LS-1.5-50
8.....	LS-1.5-50	LS-1.5-50		LS-1.5-50
9.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	
10.....	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50
11.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	LS-1.5-50

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Ben Davis Winesap Northwest Greening	1	2,295	24	1.04	674	29.37
	2	1,945	37	1.90	373	19.18
	3	2,281	39	1.71	376	16.48
	4	1,598	16	1.00	144	9.01
	5	2,154	70	3.25	172	7.99
	6	1,541	181	11.74	111	7.20
	7	1,597	229	14.34	116	7.26
	8	2,265	138	6.09	210	9.27
	9	2,490	224	9.00	106	4.26
	10	3,252	1	.03	928	28.54
	11	1,495	26	1.74	129	8.63
	check	3,285	808	24.60		

The highest efficiency (96 per cent) secured at Florence (table 25) was in plat 5, where Bordeaux was used for the first spray and lime sulphur for the three subsequent sprays. Bordeaux used for the first spray gave consistently better results than lime sulphur. For the subsequent sprays, however, Bordeaux shows no added advantage. An idea of the approximate value of each application was secured by omitting one spray for each of the plats. The evidence secured in this way indicates that, at this place, the first spray controlled more than 32 per cent of the total infection. The petal-fall spray controlled 28 per cent, the 3-weeks spray controlled 16 per cent, and the July spray controlled 24 per cent. These figures are only approximately correct, since it is impossible to determine how long a single application will be effective, but the results certainly show the relative value of the different applications for the one season.

The results here also indicate that, everything else being equal, the earlier in the season Bordeaux is used after the trees come into full bloom, the greater will be the danger of injury from spray burn.

TABLE 26—*Lincoln spray schedule*

Date Spray	April 25 Cluster-bud	May 9 Petal-fall	June 2 3-weeks	July 15 Second-brood
Flat 1.....	Bx-4-6-50	LS-1.5-50	LS-1.5-50	Bx-3-4-50
2.....	Bx-4-6-50	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50
3.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	LS-1.5-50

Scab injury on windfalls and picked fruit

Variety	Flat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Ben Davis	1	2,549	2	.07	498	19.54
	2	1,884	0	.0	580	30.78
Jonathan	3	1,428	15	1.05	125	8.75
	check	3,530	1,230	34.85		

At Lincoln table 26, the schedules for plats 1 and 2 gave approximately 100 per cent control. The complete lime sulphur schedule was 97 per cent efficient. Here again Bordeaux did considerable injury even where used only in July, but was especially injurious where used for the 3-weeks spray. The rainfall was certainly not more than normal at Lincoln in 1913, nor did it come at the most inopportune times, hence the weather cannot be largely to blame for the spray injury. These plats had been sprayed before but not cultivated. Lime sulphur injury was greater on the foliage than on the fruit.

The results of the year's work indicate that a pre-petal-fall spray is often very necessary, depending upon weather conditions. Bordeaux seems to be more effective as a fungicide than lime sulphur, but when used for the petal-fall spray or soon after that time it russets the fruit so badly that its use is inadvisable. However, for the first application it proved more desirable than lime sulphur.

EXPERIMENTS IN 1914

The same general plan of spraying was followed as in 1913 except that the dates of some of the sprays were shifted to correspond to the maturing and dissemination of the spores of the scab fungus.

The infection this year was very light, being comparatively negligible even on the check trees, in the orchards which were sprayed in 1913. In the orchards which had not been sprayed before, infection did not appear to a very noticeable extent until after the 10-days' spray had been applied. This season was exceptionally dry, and comparatively little secondary infection occurred.

TABLE 27—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 15 Petal-fall	May 25 10-days	June 12 25-days	June 22 35-days	July 14 2d-brood
Plat 1.....	Bx-4-6-50	LS-1.008			LS-1.008	LS-1.008
2.....	Bx-4-6-50	LS-1.008		LS-1.008		LS-1.008
3.....	Bx-4-6-50	LS-1.008	LS-1.008			LS-1.008
4.....	Bx-4-6-50	LS-1.008			Bx-3-4-50	LS-1.008
5.....	Bx-4-6-50	LS-1.008		Bx-3-4-50		LS-1.008
6.....	Bx-4-6-50	LS-1.008	Bx-3-4-50			LS-1.008

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Ben Davis.....	1	772	8	1.04	27	3.50
	2	3,248	32	.98	96	2.96
	3	3,485	12	.34	173	4.96
	4	5,342	16	.30	362	6.78
	5	6,074	15	.25	449	7.39
	6	2,198	16	.73	86	3.91
	check	4,377	464	10.60		
Missouri Pippin...	1	7,801	66	.85	90	1.15
	2	7,994	43	.54	191	2.39
	3	6,128	20	.33	98	1.60
	4	6,791	28	.41	66	.97
	5	8,098	12	.15	143	1.77
	6	8,141	10	.12	209	2.57
	check	10,468	1,307	12.49		
Ben Davis Missouri Pippin...	1	8,573	74	.86	117	1.36
	2	11,242	75	.67	287	2.55
	3	9,613	32	.33	271	2.82
	4	12,133	44	.36	428	3.53
	5	14,172	27	.19	592	4.18
	6	10,339	26	.25	295	2.85
	check	14,845	1,771	1.19		

At Beatrice (table 27), the highest efficiency was 98.4 per cent. There was practically no difference in any of the sprayed plats.

Neither was there any appreciable difference in the amount of spray injury caused by the late sprays of either Bordeaux or lime sulphur. Practically all the infection which occurred here must have taken place about the time of the petal-fall spray as it began to be noticeable on the check trees soon after the 10-days spray.

TABLE 28—*Seward spray schedule*

Date Spray	April 30 Cluster-bud	May 20 Petal-fall	June 18 3-weeks	July 20 Second-brood
Plat 1.	Bx-4 6-50	LS-1.008	LS-1.008	Bx-3-4-50
2.	LS-1.009	LS-1.008	LS-1.008	LS-1.008

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Ben Davis Winesap	1	5,278	128	2.42	85	1.61
	2	4,180	83	1.99	86	2.06
	check	1,982	485	24.47	.....	.....

At Seward (table 28), the same conditions prevailed as at Beatrice. Here Bordeaux for the first spray showed a slightly higher efficiency than lime sulphur.

The results of the year bear out those of 1913 in regard to the comparative efficiency of Bordeaux and lime sulphur. Bordeaux this year did little injury at any of the late sprayings, due to the excessively dry weather.

In most instances, the petal-fall was the earliest spray that was necessary this year.

EXPERIMENTS IN 1915

Since no conclusive results were obtained in 1914, owing to weather conditions, the same plans were followed in 1915. This season was very favorable to the development of scab and there was a great deal of primary as well as secondary infection. As in 1913, considerable infection occurred before the trees were in bloom. Quite a heavy secondary infection occurred from the latter part of July to the middle of August or perhaps considerably later. This secondary infection was heaviest near the check trees and in the vicinity of unsprayed orchards. In some cases more than 30 per cent of the fruit on well-sprayed trees in the vicinity of check trees was infected with small scab spots at packing time regardless of the fact that scarcely any of the windfalls from these

same trees were scabby and no scab was noted on the previous examinations of the tree.

TABLE 29—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 24 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1.....	Bx-4-4-50	LS-1.009	LS-1.009			
2.....	LS-1.01	LS-1.009	LS-1.009			
3.....	LS-1.01	LS-1.009	Bx-4-4-50			
4.....	LS-1.01	LS-1.009	Bx-4-4-50	Bx-4-4-50		
5.....	LS-1.01	LS-1.009	Bx-4-4-50		Bx-4-4-50	
6.....	LS-1.01	LS-1.009	Bx-4-4-50			Bx-4-4-50
7.....	LS-1.01	LS-1.009	Bx-4-4-50			LS-1.008

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Ben Davis.....	1	1,427	166	11.63	207	14.51
	2	1,784	242	13.56	90	5.04
	3	1,353	135	10.00	242	17.88
	4	1,848	344	18.62	119	6.44
	5	1,853	186	10.05	86	4.64
	6	1,727	0	.00	58	3.36
	7	878	12	1.37	34	3.87
	check	6,853	5,826	85.01		
Missouri Pippin...	1	1,729	155	8.96	9	.52
	2	1,351	53	3.92	79	5.85
	3	665	38	5.71	61	9.17
	4	3,069	235	7.66	328	10.69
	5					
	6	1,967	3	.28	48	4.50
	7					
	check	5,966	4,457	74.70		
Ben Davis Missouri Pippin...	1	3,156	321	10.17	216	6.84
	2	3,135	85	2.71	169	5.39
	3	2,018	38	1.88	303	15.01
	4	4,917	579	11.77	447	9.09
	5 ¹	1,853	186	10.05	86	4.64
	6	2,794	3	.11	106	3.79
	7 ¹	878	12	1.37	34	3.87
	check	12,819	10,283	80.23		

At Beatrice (table 29), the most efficient schedule was that of plat 6, which was practically 100 per cent, closely followed by plat 7, which was 98.3 per cent efficient. The schedules for the

¹No Missouri Pippin.

plats which did not receive the July spray ranged from 85.5 per cent to 89 per cent efficiency. The evidence indicates that there was quite a severe secondary infection of scab toward the latter part of the season, which was controlled on the sprayed plats by the July application.

TABLE 30—*Omaha spray schedule*

Date Spray	April 27 Cluster-bud	May 11 Petal-fal	May 22 7-days	May 29 14-days	June 11 21-days	June 25 35-days	Aug. 13 2d-brood
Plat 1	LS-1.01	LS-1.009	LS-1.009	.....	.....	.....	.....
2	LS-1.01	.....	LS-1.009	.....	.....	.....	.....
3	LS-1.01	LS-1.009	.....	LS-1.009	.....	.....	.....
4	.....	LS-1.009	.....	LS-1.009	.....	.....	.....
5	LS-1.01	LS-1.009	.....	.....	LS-1.009	.....	.....
6	LS-1.01	LS-1.009	.....	LS-1.009	.....	LS-1.009	.....
7	LS-1.01	LS-1.009	.....	LS-1.009	.....	LS-1.009	LS-1.008

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Jonathan.....	1	3,770	9	.24	863	22.89
	2	2,994	0	.0	227	7.58
	3	3,961	0	.0	142	3.58
	4	4,069	0	.0	254	6.24
	5	3,278	0	.0	294	8.97
	6	2,883	0	.0	195	6.76
	7	5,094	0	.0	409	8.03
	check	6,353	296	4.66	.....	.....
Ben Davis.....	1	994	12	1.20	222	22.33
	2	1,418	13	.92	68	4.79
	3	1,875	16	.85	163	8.69
	4	2,064	9	.44	159	7.70
	5	.....	.....	.....	.....	.....
	6	1,141	0	.0	88	7.71
	7	1,243	0	.0	113	9.09
	check	1,333	377	28.28	.....	.....
Jonathan Ben Davis.....	1	4,764	21	.44	1,085	22.77
	2	4,412	13	.29	295	6.69
	3	5,836	16	.27	305	5.23
	4	6,133	9	.15	413	6.73
	5 ¹	3,278	0	.0	294	8.97
	6	4,024	0	.0	283	7.03
	7	6,337	0	.0	522	8.24
	check	7,686	673	8.76	.....	.....

¹No Ben Davis.

At Omaha (table 30), the schedules for plats 5, 6, and 7 were 100 per cent efficient, with very little difference for the schedules of the other plats. The difference in amount of infection on some of these plats and on the check might be astonishing were it not known that the check plat was a row near a fence which could not be cultivated, while all of the sprayed plats had received clean cultivation for several years. Unless the slight difference in the efficiency of the different schedules be attributed to the natural variation to be expected or to experimental error, the evidence indicates early infection.

The spray injury is quite uniform for the different schedules except that of plat 1. The high percentage of spray injury recorded here cannot be accounted for.

At Lincoln (table 31), the evidence corroborates that of table 29 at Beatrice. The late secondary infection on the sprayed trees was heavier here than at Beatrice, tho the infection on the check trees was much lighter. This difference may be due in part to the fact that unsprayed orchards were on all sides of the plats used in the experiment, but is due in part, no doubt, to more efficient spraying at Beatrice.

The omission of a different application in each of several schedules furnishes evidence of when much of the infection occurred. It certainly proved disastrous, here, to omit the cluster-bud spray or the fungicide at the petal-fall spray as is often advocated. The control shown by the 14-days and the 21-days applications indicates that considerable infection was also occurring at this time.

TABLE 31—*Lincoln spray schedule*

Date Spray	April 26 Cluster-bud	May 10 Petal-fall	May 18 7-days	June 1 14-days	June 8 21-days	June 24 35-days	Aug. 11 12-weeks
Plat 1	.....	LS-1.009	.....	LS-1.009	.....	.....	.....
2	LS-1.01	LS-1.009	.....	LS-1.009	.....	.....	.....
3	LS-1.01	LS-1.009	LS-1.009	.....	.....	.....	.....
4	LS-1.01	.....	LS-1.009	.....	.....	.....	.....
5	LS-1.01	LS-1.009	.....	.....	LS-1.009	.....	.....
6	LS-1.01	LS-1.009	.....	LS-1.009	.....	LS-1.009	.....
7	LS-1.01	LS-1.009	.....	LS-1.009	.....	.....	LS-1.009

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Spray injury	Per cent spray injury
Jonathan.....	1	6,483	1,312	20.24	278	4.29
	2	5,840	858	14.69	175	3.00
	3	4,919	826	16.87	272	5.53
	4	5,930	1,185	19.98	409	6.90
	5	6,980	932	13.35	251	3.65
	6	4,930	824	16.71	268	5.44
	7	3,037	33	1.09	253	8.33
	check	6,410	2,123	33.12	.....	.....
Winesap.....	1	2,207	625	28.34	0	.0
	2	2,501	325	13.00	0	.0
	3	2,582	541	20.95	12	.46
	4	3,015	459	15.22	49	1.62
	5	1,385	173	12.49	4	.03
	6	.....	.....	.....	.....	.....
	7	2,867	88	3.07	13	.45
	check	2,343	2,009	85.75	.....	.....
Ben Davis.....	1	1,498	355	23.70	0	.0
	2	1,806	216	12.00	0	.0
	3	2,088	1,260	60.35	35	1.68
	4	1,714	556	32.44	15	.88
	5	1,867	209	11.19	27	1.45
	6	2,225	217	9.75	16	.72
	7	2,057	77	3.74	132	6.42
	check	.....	.....	.....	.....	.....
Combined varieties	1	10,188	2,292	22.50	278	2.73
	2	10,147	1,399	13.78	175	1.72
	3	9,589	2,627	27.39	319	3.33
	4	10,659	2,200	20.63	473	4.44
	5	10,232	1,314	12.84	282	2.76
	6	7,155	1,041	14.54	284	3.97
	7	7,961	198	2.49	398	5.00
	check	11,633	6,188	53.19	.....	.....

TABLE 32—*Lincoln spray schedule*

Date Spray	April 26 Cluster-bud	May 10 Petal-fall	May 18 7-days	June 1 14-days	June 8 21-days	June 24 35-days	Aug. 11 12-weeks
Plat 1	.....	LS-1.009	.....	LS-1.009	.....	.....	LS-1.009
2	LS-1.01	LS-1.009	.....	LS-1.009	.....	.....	LS-1.009
3	LS-1.01	LS-1.009	LS-1.009	.....	.....	.....	LS-1.009
4	LS-1.01	.....	LS-1.009	.....	.....	.....	LS-1.009
5	LS-1.01	LS-1.009	.....	.....	LS-1.009	.....	LS-1.009
6	LS-1.01	LS-1.009	.....	LS-1.009	.....	LS-1.009	LS-1.009

Scab injury on windfalls and picked fruit

Variety	Plat	Total fruit	Scab	Per cent scab	Srray injury	Per cent spray injury
Jonathan.....	1	6,744	357	5.29	238	3.53
	2	3,037	33	1.09	253	8.33
	3	5,753	349	6.06	82	1.43
	4	4,976	429	8.62	178	3.58
	5	5,068	43	.85	299	5.90
	6	4,463	59	1.32	250	5.60
	check	6,410	2,123	33.12	.....	.....
Winesap.....	1	3,692	579	15.68	0	.0
	2	2,867	88	3.07	13	.45
	3	2,918	236	8.06	60	2.06
	4	2,731	485	17.76	46	1.68
	5	2,274	38	1.67	3	.13
	6	.....	.....	.....	.....	.....
	check	2,343	2,009	85.74	.....	.....
Ben Davis.....	1	2,057	226	1.09	42	2.04
	2	2,057	77	3.74	132	6.42
	3	2,214	111	5.01	18	.81
	4	2,221	230	10.35	7	.32
	5	1,953	89	4.56	52	2.66
	6	2,486	184	7.40	22	.88
	check	2,880	2,056	71.39	.....	.....
Jonathan Winesap Ben Davis.....	1	12,493	1,162	9.30	280	2.24
	2	7,961	198	2.49	398	5.00
	3	10,885	696	6.39	160	1.47
	4	9,928	1,144	11.52	231	2.33
	5	9,295	170	1.83	354	3.81
	6 ¹	6,949	243	3.50	272	3.91
	check	11,633	6,188	53.19	.....	.....

Table 32 gives further evidence of a primary infection which occurred during a period of several days, beginning soon after

¹Only Jonathan and Ben Davis.

the flower buds began to show pink and lasting until after the petals had fallen. Evidently there was also considerable infection during the period between the 14-days and the 21-days spray. The fact that all the plats in table 32 are consistent in showing less scab infection than the corresponding plats shown in table 31 is conclusive evidence of a late secondary infection which occurred at such time that the August spray controlled it to a great extent.

INCIDENTAL OBSERVATIONS

During the past three seasons a number of observations were made which were not scheduled in the regular plans.

In securing the records, it was noted that there was considerable consistent variation in the amount of infection on different varieties of apples. This led to a study of all the available varieties, to determine which, if any, were resistant to scab. After three seasons of this work, it was found that the records of a variety for one season did not always correspond with the records of the same variety for another season; e. g., the variety Winesap is usually considered much more susceptible than Ben Davis. The records bear this out for 1913 and 1914, but in 1915 scab was, in many instances, more prevalent on Ben Davis apples than on Winesap. On the average perhaps this is not true. It was also found that none of the common varieties are entirely free from scab, altho many varieties exhibit a great deal of resistance. On comparing observations made with the results previously reported by other workers, this variation in susceptibility is emphasized. Wallace (1913) makes a similar statement and quotes extracts from other publications.

From the observations made in various orchards in the State and in the variety orchard at the Experiment Station the varieties have been tentatively grouped as follows:

<i>Practically resistant</i>	<i>Moderately resistant</i>	<i>Susceptible</i>
Wagner	Jonathan	Arkansas (Mammoth)
Oldenburg (Duchess)	York (Imperial)	Blacktwig)
Wealthy	Ben Davis	Ralls (Jenet)
Patten Greening	Windsor	Northern Spy
	Gano	Red June
	Grimes (Golden)	Virginia Beauty
	Missouri (Pippin)	Yellow Transparent
	Salome	Sheriff
	Champion	Maiden Blush
	Minkler	Walbridge

<i>Practically resistant</i>	<i>Moderately resistant</i>	<i>Susceptible</i>
	Northwest Greening	Early Harvest
	Rome Beauty	Fameuse (Snow)
	Delicious	King David
	Red Astrachan	Chenango
	Wolf River	Paragon
	Malinda	
	Willow Twig	
	Stayman Winesap	
	Chicago	
	Utter (Red)	

Scab was always found to be more prevalent where no cultivation was practiced and decidedly less in evidence where thoro, early and late cultivation was practiced as in the case of the Beavers orchard at Omaha.

Well pruned and spaced trees were as a rule less scabby than trees which carried a dense foliage or which were so close together that the branches interlocked. This should be expected, since the more dense the foliage the longer the tree will remain moist and afford the best conditions for the germination of spores.

It was noticed that trees situated on high, rolling land were usually not so badly infected as trees on lower ground. This is due in part to the better circulation of air on the rolling land and in part to the dense foliage found on trees growing in low places, especially where proper pruning is not given.

SUMMARY

The foregoing records and observations lead to some more or less general conclusions.

Sanitation, i.e., the removal of old leaves, windfalls, and mummied apples, together with clean culture, will go a long way towards controlling the primary infection.

The proper spacing of the trees in an orchard, together with good air drainage and the right amount of pruning, will lessen the infection to some extent. However, even with an ideal orchard and the best methods of sanitation, clean fruit cannot be grown in Nebraska unless the orchards are properly sprayed.

The evidence presented shows that spraying will control the disease if applied at the proper time and that this time depends upon the time of infection. The spray must be applied before the infection in order to prevent injury. Therefore, since it has been proved that there is always more or less infection at or just before the time the blossoms are out if the weather conditions are favorable, it follows that spraying for scab must be done before

this time. What is known as the cluster-bud stage, just as the flowers of the clusters are separating and showing "pink" but before the individual blossoms open, is the proper time for this application, according to results obtained. In dry seasons or in orchards where thoro spraying and orchard sanitation have been the rule, this application may be omitted without serious loss as shown by the results obtained in most of the orchards in 1914 and in the Omaha orchard (table 30) in 1915.

A second application at the petal-fall stage, and another two to three weeks later, are as a rule required to insure protection. During this time new surfaces of fruit and foliage are being rapidly exposed and are liable to infection. Another spray in the latter part of July or the first part of August may be necessary to prevent late infection in wet seasons such as that of 1915.

In order to secure the best results, it is necessary that the grower watch the weather conditions carefully and regulate his schedule accordingly. Thousands of bushels of apples have been lost in this State because the grower delayed spraying on account of rainy weather, fearing the spray would wash off. This is just the time when protection is needed to prevent infection. There is rarely a season in Nebraska when, because of wet weather, there is not sufficient time to spray, and if it is possible to work for only a part of a day at a time, spraying should proceed. Ordinarily the spray material will dry in 30 minutes of sunshine so that it will adhere well thru any ordinary hard washing rain.

APPLE BLOTCH

Spraying experiments were begun in 1913, primarily to determine efficient methods of control for codling moth, plum curculio, and apple scab, but it was soon discovered that apple blotch was more destructive in some parts of the state than apple scab. The disease was carefully observed during the season and notes taken on the efficiency of the sprays, intended for scab, in controlling blotch. This disease has only recently invaded Nebraska from the south and east and as yet is serious only in the southeastern portion of the State. It is widely distributed over the United States. The writer had abundant opportunity to observe its destructiveness in Kansas in 1910, '11, and '12, where in some sections it causes more damage than any other disease which attacks the apple.

DESCRIPTION AND BEHAVIOR

The fungus attacks fruit spurs, twigs, and rapidly growing shoots, producing characteristic cankers (Scott and Rorer, 1909).

(1909) Scott, W. P. and Rorer, James B. Apple blotch a serious disease of southern orchards. U. S. D. A. Bul. No. 144.

Scott and Rorer further say, in effect: On the fruiting branches the cankers appear first as small purple or blackish blotches. As they increase in size they become brown in the center with a purple margin but finally become gray. The bark soon cracks around the cankers, especially along the lateral edges. On rapidly growing shoots, particularly water sprouts, the cankers have the same



Fig. 9—Blotch cankers on twigs

general appearance as on fruiting branches, but are much larger, often measuring an inch or more in length and sometimes girdling the stem. The fungus lives over winter in the cankers, which become larger from year to year and may continue to grow for several seasons. Frequently, however, the cankers are cut off from the healthy tissue by cracks, dry up, and later the wound may heal over.

The cankers themselves do not, as a rule, seriously injure the tree, but in some cases, on susceptible varieties, such as Northwest Greening, Missouri, Limber Twig, and Red Astrachan, the trees may become so badly affected that much of the bearing wood will be killed and the trees materially weakened. The leaves also are attacked, the fungus causing irregular light brown, yellowish, or whitish spots, measuring $\frac{1}{16}$ inch or less in diameter. The spots often appear in great numbers scattered promiscuously over the surface of the leaf, on the veins, midrib, and petiole. The

badly infected leaves may turn yellow and drop prematurely, or die, turn brown, and remain on the tree. This results in a weakening and in many cases the death of the fruit buds for the following year's crop.

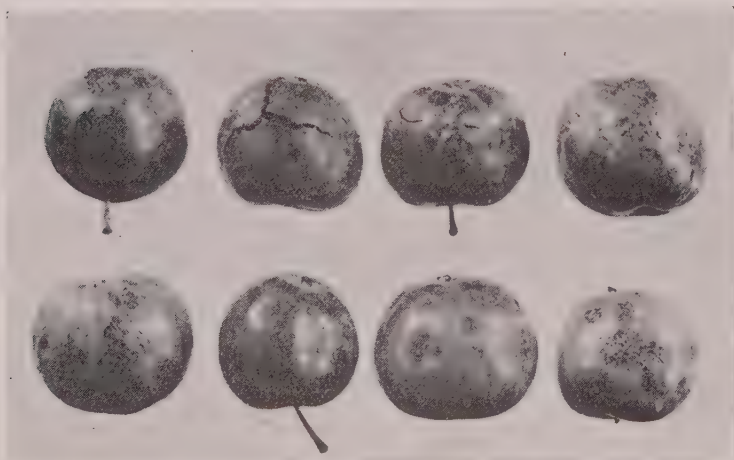


Fig. 10—Blotch on young fruit

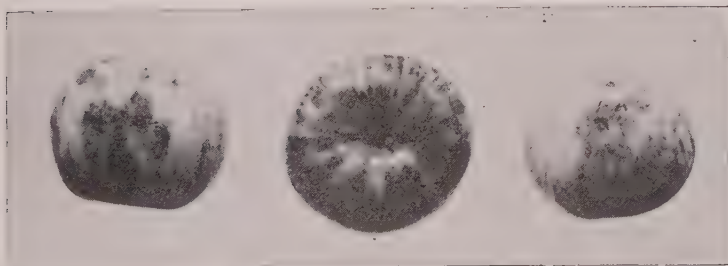


Fig. 11—Blotch on mature fruit

"The first evidence of the disease on the fruit is a very small, inconspicuous light brown blot which under a hand lens has the appearance of a stellate collection of brown fibers just beneath the epidermis."

The blotch spreads rapidly until it attains a size of from one-eighth to three-eighths of an inch or even larger and becomes

darker in color. The advancing margin is irregular and jagged and has a fringed appearance. Where the spots are numerous they often coalesce and form large blotches which may cover half or more of the fruit. The fungus kills only the superficial cells so that the continued growth of the tissue beneath results in a cracking of the diseased areas. These cracks tho usually small may girdle the fruit and extend to the core. The general effect is to mar the appearance of the fruit and render it unfit for packing.

INFECTION

According to Scott and Rorer the cankers in which the fungus passes the winter are the chief source of infection. Spores are produced during the warm, moist weather of spring, which are readily carried by the rain and other agencies to the young fruit, leaves, and twigs, producing the first spring outbreak of the disease. The primary and most extensive infection begins 4 to 5 weeks after the petals have fallen, altho some infection probably occurs during the remainder of the growing season.

EXPERIMENTS IN 1913

No special attention was given to blotch when the schedules for 1913 were outlined, but notes were taken on time and amounts of infection and the degree of control afforded by each schedule.

TABLE 33—*Wymore spray schedule*

Date Spray	April 21 Cluster-bud	May 5 Petal-fall	May 22 Three-weeks	July 2 Second-brood
Plat 1.....	LS-1.5-50	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50
2.....	LS-1.5-50	LS-1.5-50	Bx-3-4-50	Bx-3-4-50
3.....	LS-1.5-50	LS-1.5-50	LS-1.5-50	LS-1.5-50
4.....	Bx-3-4-50	LS-1.5-50	LS-1.5-50	Bx-3-4-50

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Two Ben Davis and two Missouri Pippin trees in each plat	1	1,863	4	.21	49	2.63
	2	3,182	24	.75	192	6.03
	3	2,022	393	19.43	152	7.52
	4	3,405	553	16.24	216	6.34
	check	2,203	551	25.01		

At Wymore (table 33), the efficiency of the lime sulphur schedule (plat 3) was only 23 per cent, while that of the Bordeaux schedule (plat 1) was 99 per cent, and of plat 2 was 97 per cent. This indicates that the application of Bordeaux made three weeks

after the falling of the petals prevented most of the infection. The fact that the Bordeaux spray applied July 2 was slightly more efficient than lime sulphur applied at the same time indicates that some infection occurred after that date.

The first blotch spots were found on the fruit on July 3, about 7 weeks after the petals had fallen from the trees. This would indicate that the infection occurred not more than 4 weeks after the petals fell.

TABLE 34—*Brownville spray schedule*

Date Spray	May 6 Petal-fall	May 30 Three-weeks
Plat 1.....	LS-1. 5-50	LS-1. 5-50
2.....	LS-1. 5-50	Bx-3-4-50
3.....	LS-1. 5-50	Bx-3-4-50
7.....	Bx-3-4-50	Bx-3-4-50

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis and Mis- souri Pippin, two trees of each variety to a row examined	1	4,790	473	9.87	49	1.02
	2	5,774	298	5.16	40	.69
	3	4,638	100	2.16	15	.32
	7	5,071	127	2.50	2,132	42.04
	check	1,804	437	24.22		

At Brownville (table 34), the evidence indicates that the three-weeks spray controlled the greater part of the infection. Bordeaux used at this time was 31.8 per cent more efficient than lime sulphur. Bordeaux used for the petal-fall spray showed no advantage over lime sulphur, but on the other hand greatly injured a high per cent of the crop. The indications are that the heavy infection occurred soon after the three-weeks spray and that some infection occurred later in the season.

EXPERIMENTS IN 1914

Special stress was laid on determining the date and length of the infection period as well as methods of control. Observations were made in an unsprayed orchard near Lincoln and in the orchards where spraying was done. Spores were found issuing from the cankers in large numbers on June 5 at Beatrice and Wymore and on June 8 at Lincoln. Spores may have been freed before this time. As blotch cankers were not plentiful at Beatrice or Wymore it was impossible to secure definite data at these places. At

Lincoln they were more plentiful and spores continued to issue from some of them for nearly three weeks in large numbers, and in greatly reduced numbers for several days longer. The spray schedules were so arranged that plats could be sprayed at intervals of about 10 days during the heavy dissemination of spores. The severe injury due to Bordeaux russetting, together with the fact that Bordeaux proved more efficient than lime sulphur, led to an interchange of Bordeaux and lime sulphur applications in some of the schedules in order to ascertain if it were not possible to control blotch with a minimum amount of injury.

TABLE 35—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 15 Petal-fall	May 25 10-days	June 12 25-days	June 22 35-days	July 14 2d-brood
Plat 1.....	Bx-4-6-50	LS-1.008	.....	.....	LS 1.008	LS-1.008
2.....	Bx-4-6-50	LS-1.008	.....	LS-1.008	.....	LS-1.008
3.....	Bx-4-6-50	LS-1.008	LS-1.008	.....	.....	LS-1.008
4.....	Bx-4-6-50	LS-1.008	.....	.....	Bx-3-4-50	LS-1.008
5.....	Bx-4-6-50	LS-1.008	.....	Bx-3-4-50	.....	LS-1.008
6.....	Bx-4-6-50	LS-1.008	Bx-3-4-50	.....	.....	LS-1.008

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis....	1	772	7	.91	27	3.50
	2	3,248	12	.37	96	2.96
	3	3,485	17	.49	173	4.96
	4	5,342	19	.36	362	6.78
	5	6,074	8	.13	449	7.39
	6	2,198	0	.0	86	3.91
	check	4,377	470	10.74	.....	.....
Mo. Pippin....	1	7,801	230	2.95	90	1.15
	2	7,994	173	2.16	191	2.39
	3	6,128	182	2.97	98	1.60
	4	6,791	58	.85	66	.97
	5	8,098	70	.86	143	1.77
	6	8,141	30	.37	229	2.57
	check	10,468	1,370	13.09	.....	.....
Ben Davis Mo. Pippin....	1	8,573	237	2.76	117	1.36
	2	11,242	185	1.65	287	2.55
	3	9,613	199	2.07	271	2.81
	4	12,133	77	.63	428	3.52
	5	14,172	78	.55	592	4.1
	6	10,339	30	.29	295	2.85
	check	14,845	1,840	12.39	.....	.....

At Beatrice (table 35), Bordeaux proved only 11 per cent more efficient than lime sulphur. Since the 35-days spray prevented practically as much injury as either of the two preceding sprays, it would indicate that most of the infection did not take place until or after this time.

TABLE 36—*Wymore spray schedule*

Date Spray	April 23 Cluster-bud	May 14 Petal-fall	June 10 Three-weeks	July 12 Second-brood
Plat 1	Bx-4-6-50	Bx-3-4-50	Bx-3-4-50	Bx-3-4-50
2	LS-1.009	LS-1.008	LS-1.008	LS-1.008

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis	1	5,703	44	.77	180	3.16
Mo. Pippin	2	5,603	292	5.21	156	2.78
	check	4,063	100	2.46	.....	.....

At Wymore (table 36), Bordeaux again proved superior to lime sulphur in controlling blotch. There was considerable more blotch injury on the lime sulphur plat than on the check plat. The check plat was sprayed four times with Bordeaux in 1913. This may account for the lack of infection in 1914.

The results of the work in 1914, while not conclusive, shed considerable light on the possibility, and methods, of controlling blotch. Considering the time when the first spores were liberated, if the proper weather conditions exist infection should begin about three weeks after the petals fall. The finding of some blotched fruit on July 8 at Lincoln and July 10 at Beatrice would also indicate that infection may occur earlier than was suggested by Scott and Rorer. Lewis (1913) also suggested that this was the case in Kansas. However, the fact that the 35-days spray was almost as efficient in controlling the disease as the 10-days or the 25-days spray shows that most of the infection occurred not sooner than 5 weeks after the petals had fallen. As in 1913, Bordeaux proved more efficient than lime sulphur.

EXPERIMENTS IN 1915

The same general plans of procedure were followed as in 1914, except that the experiments for the control of blotch were confined

to one orchard. Observations were made chiefly at Lincoln. Spores were found exuding on June 2. They were more abundant than in 1913 or 1914, and could be found in fairly large quantities for 20 days and in smaller quantities for several days longer.

TABLE 37—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 25 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1.....	Bx-4-4-50	LS-1.009	LS-1.009			LS-1.008
2.....	LS-1.01	LS-1.009	Bx-4-4-50			LS-1.008
3.....	LS-1.01	LS-1.009		Bx-4-4-50		LS-1.008
4.....	LS-1.01	LS-1.009	LS-1.009		Bx-4-4-50	LS-1.008
5.....	LS-1.01	LS-1.009	LS-1.009			LS-1.008

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis....	1	1,602	237	14.79	84	5.24
	2	2,303	0	.0	425	18.45
	3	3,069	53	1.73	328	10.69
	4	1,733	3	.17	130	7.50
	5	878	166	18.91	34	3.87
	check	6,853	2,217	32.35		
Mo. Pippin....	1	1,510	551	36.49	8	.53
	2	1,109	84	7.57	123	11.09
	3	2,631	27	1.03	250	9.50
	4	2,037	58	2.85	16	.78
	5	2,417	501	20.73	80	3.31
	6 ¹	1,996	849	42.53	176	8.82
	check	5,966	3,320	55.65		
Ben Davis Mo. Pippin	1	3,112	788	25.32	92	2.96
	2	3,412	84	2.46	548	16.06
	3	5,700	80	1.40	578	10.14
	4	3,770	61	1.62	146	3.87
	5	3,295	667	20.24	114	3.46
	6 ²	1,996	849	42.53	176	8.82
	check	12,819	5,537	43.20		

The evidence shown in table 37 indicates that while some infection must have taken place earlier, the greater part of it occurred after the 35-days spray. Blotched apples were first found the last of June. This also indicates early infection.

¹Not sprayed in 1914. Received same treatment as plat 5 in 1915.²No Ben Davis.

Bordeaux proved to be higher in efficiency than lime sulphur but the 14-days application did considerable damage by russetting the fruit. The 21-days application did more damage than the 35-days spray. Plat 6 showed almost as much infection as the check plat. Here, however, only the variety Missouri Pippin was considered. This variety is much more susceptible to blotch than the Ben Davis.

TABLE 38—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 25 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1.....	Bx-4-4-50	LS-1.009	LS-1.009	.....	.....	.....
2.....	LS-1.01	LS-1.009	Bx-4-4-50	.....	.....	.....
3.....	LS-1.01	LS-1.009	.....	Bx-4-4-50	.....	.....
4.....	LS-1.01	LS-1.009	LS-1.009	.....	Bx-4-4-50	.....
5.....	LS-1.01	LS-1.009	LS-1.009	.....	.....	.....

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis....	1	1,427	162	11.35	207	14.51
	2	1,353	6	.44	242	17.88
	3	1,848	19	1.03	119	6.44
	4	1,853	18	.97	86	4.64
	5	1,938	220	11.35	79	4.08
	check	6,853	2,217	32.35	.....	.....
Mo. Pippin....	1	1,729	391	22.61	9	.52
	2	665	58	8.72	61	9.17
	3	3,069	53	1.73	328	10.69
	4	1,784	28	1.57	132	7.40
	5	1,351	328	24.28	79	5.85
	check	5,966	3,320	55.65	.....	.....
Ben Davis Mo. Pippin....	1	3,156	553	17.52	216	6.84
	2	2,018	64	3.17	303	15.01
	3	4,917	72	1.46	447	9.09
	4	3,637	46	1.26	218	5.99
	5	3,289	548	16.66	158	4.80
	check	12,819	5,537	43.20	.....	.....

The evidence shown in table 38 corroborates that shown in table 37. In addition it indicates that a lime sulphur application on August 10 was of no value for control of blotch. Here it will be noticed that in contrast to table 37 lime sulphur for the 14-days spray was 61.5 per cent efficient. In fact, the efficiency of the

schedules for both plats 1 and 5 was for some unaccountable reason considerably higher than for the corresponding plats in table 37.

TABLE 39—*Beatrice spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 25 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1. . . .	Bx-4-4-50	LS-1.009	LS-1.009	.....	.....	Bx-4-4-50
2. . . .	LS-1.01	LS-1.009	Bx-4-4-50	.....	.....	Bx-4-4-50
3. . . .	LS-1.01	LS-1.009	.....	Bx-4-4-50	.....	Bx-4-4-50
4. . . .	LS-1.01	LS-1.009	LS-1.009	.....	Bx-4-4-50	Bx-4-4-50
5. . . .	LS-1.01	LS-1.009	LS-1.009	.....	.....	Bx-4-4-50

Blotch injury on windfalls and picked fruit

Variety	Plat	Total fruit	Blotch	Per cent blotch	Spray injury	Per cent spray injury
Ben Davis. . . .	1	2,112	224	10.60	551	26.09
	2	.....	.....	.....	.....	.....
	3	4,711	2	.04	606	12.86
	4	.....	.....	.....	.....	.....
	5	1,727	217	12.56	58	3.36
	check	6,853	2,217	32.35	.....	.....
Mo. Pippin. . . .	1	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....
	4	2,084	32	1.54	159	7.63
	5	1,067	230	21.55	48	4.50
	check	5,966	3,320	55.65	.....	.....
Ben Davis Mo. Pippin. . . .	¹ 1	2,112	224	10.60	551	26.09
	2	.....	.....	.....	.....	.....
	¹ 3	4,711	2	.04	606	12.86
	² 4	2,084	32	1.54	159	7.63
	5	2,794	447	16.00	106	3.79
	check	12,819	5,537	43.20	.....	.....

The results shown in table 39 are quite similar to those of the two preceding tables. In this case, however, the 21-days spray shows an efficiency of 100 per cent and practically as much is shown for the 35-days spray, but the 14-days spray permitted some infection. The writer is of the opinion that infection did not take place until after the 14-days spray, and the Bordeaux, being effective for a longer period than lime sulphur, prevented infection. It is very probable that some infection occurred on plat 4 before the spray was put on.

¹No Mo. Pippin.²No Ben Davis.

INCIDENTAL OBSERVATIONS

At Brownville in 1913, considerable summer pruning was done on plat 3. This consisted in the removal of dead and diseased wood and a general thinning out of the tops of the trees. At this time all blotch cankers which could be found were removed. To no other reason can be ascribed the difference in amount of blotch on plats 2 and 3. This difference, while not extraordinary, indicates what may be accomplished in this way. The greatest amount of infection seems to occur from about 3 to 5 weeks after the petals fall. The exact time between these two dates depends upon weather conditions. Infection occurs more readily and abundantly if the weather is warm and moist.

Blotch attacks fruit spurs as well as small branches and water sprouts. At the Hartley orchard, north of Lincoln, an examination of a number of Mann apple trees revealed the fact that on two of these which were infected the worst, 20 per cent of the spurs were dead and on the remaining spurs more than 30 per cent of the buds were killed. This mortality could be attributed only to blotch injury, since the trees were otherwise in a good state of health.

Grouped according to susceptibility as observed during the last three seasons, the common varieties rank as follows:

<i>Practically resistant</i>	<i>Moderately resistant</i>	<i>Susceptible</i>
Grimes (Golden)	Lawver	Mann
York (Imperial)	Ralls (Jenet)	Missouri (Pippin)
Winesap	Minkler	Maiden Blush
Stayman	Rome	Northwest Greening
Wealthy	Arkansas (Mammoth	Ben Davis
	Blacktwig)	
	Arkansas Black	

This list is very short, owing to the lack of varieties in the orchards under observation. As in the case of resistance to scab, there was some variation of the comparative resistance of the different varieties.

SUMMARY

The results of experiments and observations during the past three seasons indicate that apple blotch on the fruit can be controlled entirely by spraying alone, but the eradication of the disease may be facilitated by supplementing a thoro spraying campaign with the pruning out of affected wood.

Bordeaux was found more effective than lime sulphur, but at the same time it was found to cause considerable injury to the fruit by russetting it. The injury was found to be greatest when Bordeaux was used at or soon after the time when the petals fall.

Injury from russetting gradually diminishes as the apples become larger, altho there is always more or less danger in employing this fungicide even late in the season. When the mixture is properly made, the injury from Bordeaux compared with the advantages of its use, in combating blotch, is so small that in badly infected orchards it is recommended for the 3-weeks spray and subsequent applications.

For this purpose the 3-4-50 formula is recommended, tho if a good grade of fresh stone lime is used (not air-slacked or hydrated lime) the 3-3-50 formula is equally good. During dry weather the 4-4-50 formula has given good results but is not so safe when used during wet weather.

The indications are that three weeks after the petals fall is soon enough for the first spray for blotch, and in orchards no more badly infected than were those in which the records were made, i.e., 12 per cent to 45 per cent, this spray, followed by another application of fungicide when spraying for the second brood of codling moth, is usually sufficient. In orchards more heavily infected, no doubt another application of Bordeaux, 15 to 20 days after the 3-weeks spray, would prove very beneficial.

CEDAR RUST ON APPLES

During the three seasons just past, sufficient data could not be secured to warrant any statements by the writer on methods of controlling this disease. The comparatively dry seasons preceding these experiments probably did not offer the best conditions for the advancement of the disease. A report published

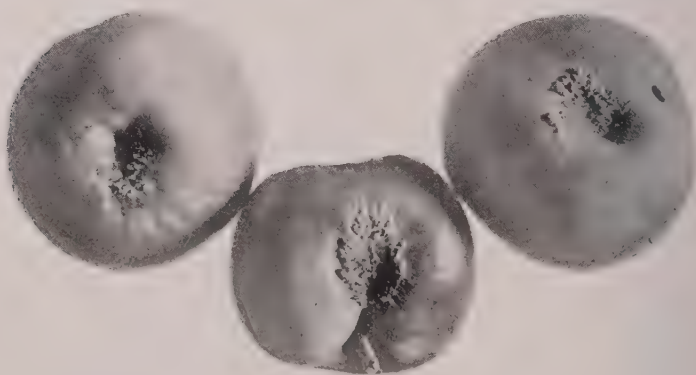


Fig. 12—Cedar rust on fruit

from this Station by Emerson in 1913 shows that the first or cluster-bud spray has comparatively no effect on the amount of injury from rust, but that the petal-fall spray and the one following give a very high per cent of control.



Fig. 13—Cedar rust on apple leaves

In order to secure the best results, spraying should be given as soon as the knots on the cedar trees known as "cedar apples" begin to enlarge and show gelatinous orange-colored exudations. This orange-colored mass contains the spores which spread to the apple trees and produce the well-known orange-colored blemishes on fruit and leaves.

SOOTY BLOTCH AND FLYSPECK

Sooty blotch and flyspeck are considered by most pathologists to be caused by the same fungus and were so treated in the

observations on which this report is based. The fungus attacks the fruit late in the season and is entirely superficial, the loss being due to discoloration, reducing the salability of the fruit. The fungus is most abundant during wet seasons and does the most damage to fruit in the lower parts of the orchard where air drainage is poor or where the trees stand too close together or are not properly pruned.

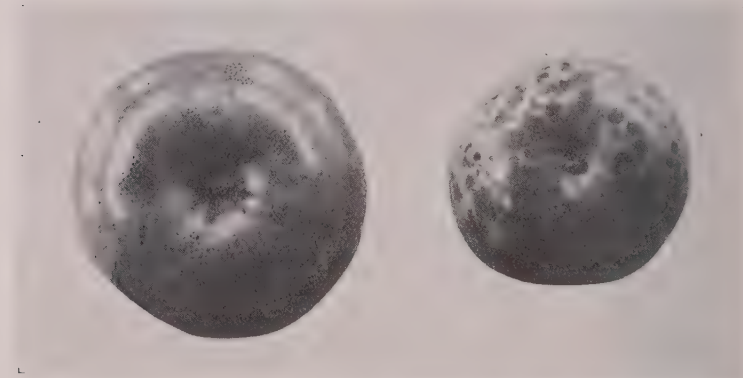


Fig. 14—Sooty blotch or flyspeck on fruit

Observations indicate that with proper pruning to admit air and light the disease will be incidentally controlled in spraying for blotch and scab.

BORDEAUX VS. LIME SULPHUR

Bordeaux has long been considered as the specific for all fungous diseases and has upheld its reputation in so far as controlling diseases is concerned. However, a great deal of injury to fruit and foliage often accompanies its use. In searching for a substitute, lime sulphur was found to be the most satisfactory material as a fungicide. Its fungicidal properties may not be quite so pronounced as those of Bordeaux, but the small amount of injury accompanying its judicious use, together with its insecticidal value, often makes it more desirable than Bordeaux. Experiments were begun at this Station to determine the relative value of each for general spraying purposes. The three seasons during which the tests were carried on offer ample variations in weather conditions to permit of rather general conclusions as to the value of each and the conditions which encourage injury from the use of either.

EXPERIMENTS IN 1913

In addition to the data on this subject given in connection with scab and blotch control, data were taken as to the effect of Bordeaux and lime sulphur on insects and diseases in general as well as to the amount of sound, clean fruit resulting from the use of either material. In making Bordeaux, the orthodox method of mixing was followed, i. e., the diluted lime and copper sulphate were poured simultaneously into a mixing tank or into the spray tank. A high grade of lime was used and all coarse material, grit, etc., removed by straining.

TABLE 40—*Spray schedule*

Date Spray	April 25 Cluster-bud	May 5 Petal-fall	May 22 3-weeks	July 2 Second-brood
Plat 1	LS-Pb 1.5-2-50	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50
2	LS-Pb 1.5-2-50	LS-Pb 1.5-2-50	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50
3	LS-Pb 1.5-2-50	LS-Pb 1.5-2-50	LS-Pb 1.5-2-50	Bx-Pb 3-4-2-50
4	Bx-Pb 3-4-2-50	LS-Pb 1.5-2-50	LS-Pb 1.5-2-50	Bx-Pb 3-4-2-50

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations indicate percentages*

Variety	Plat	Codling moth	Curculio		Scab	Blotch	Sooty blotch	Spray injury	Sound fruit
			worms	stings					
Ben Davis Mo. Pippin	1	11.00	.21	.53		.21		2.63	86.80
	2	10.74	.126	.56		.75		6.03	83.03
	3	11.17	.49	.44	.05	19.44		7.52	78.54
	4	11.07	.17	.53	.03	16.24		6.34	80.53
	check	49.02	.59	9.71	8.58	25.01	1.91		12.21

No rust was present on any of the trees.

At Wymore (table 40), there was little or no evidence of any difference in the amount of insect infestation. Scab was equally well controlled by either fungicide. Bordeaux, however, showed decidedly more efficiency in controlling apple blotch, the difference in efficiency being approximately 69 per cent. There was practically no difference in the amount of spray injury. The lack of Bordeaux injury on the fruit is no doubt due to the fact that dry weather followed the applications. Bordeaux injury to the foliage was quite noticeable. This was also true of lime sulphur injury. The higher percentage of sound fruit, i. e., fruit free from any insect or fungous injury or spray russet, in plats 1

and 2 is due chiefly to the presence of blotch, which, as has already been shown, is more thoroly controlled by Bordeaux.

TABLE 41—*Spray schedule*

Date Spray	April 24 Cluster-bud	May 10 Petal-fall	June 3 3-weeks	July 16 Second-brood
	Bx Pb	Bx-Pb	Bx-Pb	Bx-Pb
Plat 1.....	3-4-2-50	3-4-2-50	3-4-2-50	3-4-2-50
	Bx-Pb	LS-Pb	Bx-Pb	Bx-Pb
2.....	3-4-2-50	1.5-2-50	3-4-2-50	3-4-2-50
	Bx-Pb	LS-Pb	LS-Pb	Bx-Pb
3.....	3-4-2-50	1.5-2-50	1.5-2-50	1.5-2-50
	Bx-Pb	LS-Pb	LS-Pb	LS-Pb
4.....	1.5-2-50	1.5-2-50	1.5-2-50	1.5-2-50
	LS-Pb	LS-Pb	LS-Pb	LS-Pb
5.....	1.5-2-50	1.5-2-50	1.5-2-50	1.5-2-50
	Bx-Pb	Bx-Pb	Bx-Pb	Bx-Pb
6.....	3-3-2-50	3-3-2-50	3-3-2-50	3-3-2-50
	LS-Pb	LS-Pb	LS-Pb	LS-Pb
7.....	1.5-2-50	1.5-2-50	1.5-2-50	1.5-2-50

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations in percentages*

Variety	Plat	Codling moth	Curculio worms and stings	Scab	Sooty blotch	Spray injury	Sound fruit
Ben Davis Winesap	1	12.94	.08	1.05	.....	29.37	64.19
	2	10.44	.15	1.90	.....	19.18	70.49
	3	11.18	.13	1.71	.....	16.48	73.48
	4	12.70	.44	1.00	.....	9.01	77.29
	5	7.66	.14	3.25	.....	7.98	81.06
	6	8.12	.80	.03	.....	28.54	69.01
	7	8.03	2.54	1.74	.....	8.63	82.94
	check	69.59	8.67	24.60	.85	.....	10.29

No blotch or rust was present on any of the fruit.

At Florence (table 41), there is no conclusive evidence in favor of either fungicide except in the amount of spray injury. The greatest injury occurred where Bordeaux was used for the petal-fall spray.

The weather conditions were such as to induce the most serious burning by either fungicide. High hot winds prevailed during the petal-fall spray, followed by wet weather. Wet weather followed the 3-weeks application. The last application was made just after a severe hailstorm which had injured both fruit and foliage to a considerable extent, and was followed by two days of extremely hot weather after which came more rain. Both fruit and foliage were badly burned. The use of an excess of lime

in making the Bordeaux was of no advantage in preventing spray injury.

The amount of sound fruit here on the different plats seems to have been in inverse proportion to the spray injury.

TABLE 42—*Spray schedule*

Date Spray	April 25 Cluster-bud	May 9 Petal-fall	June 2 3-weeks	July 15 Second brood
Plat 1.....	Bx-Pb 3-4-3-50	Bx-Pb 3-4-3-50	Bx-Pb 3-4-3-50	Bx-Pb 3-4-3-50
2.....	Bx-Pb 3-4-3-50	LS-Pb 1.5-3-50	LS-Pb 1.5-3-50	Bx-Pb 3-4-3-50
3.....	LS-Pb 1.5-3-50	LS-Pb 1.5-3-50	LS-Pb 1.5-3-50	LS-Pb 1.5-3-50
4.....	Bx-Pb 4-4-3-50	Bx-Pb 4 4 3-50	Bx-Pb 4-4-3-50	Bx-Pb 4-4-3-50

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations are in percentages*

Variety	Plat	Codling moth	Curculio worm and sting	Scab	Spray injury	Sound fruit
Ben Davis Jonathan....	1	13.70	1.43	.26	30.79	54.14
	2	10.71	.94	.078	19.53	76.85
	3	10.71	.49	1.05	8.75	86.70
	4	20.78	.27	.65	21.21	59.20
	check	33.20	5.86	34.85	.....	34.08

No blotch, sooty blotch, or rust was present.

At Lincoln (table 42), the results were practically the same as at Florence. Bordeaux made according to the 4-4-50 formula was no more effective than the 3-4-50 Bordeaux. Neither did it cause any more injury; in fact the injury on this plat was less than in plat 1. There was one tree in plat 1 which had much more injury than any other tree of either plat.

There was more codling moth injury on the Bordeaux plats than on the lime sulphur plats. This difference is attributed to some extent to the greater amount of spray injury found on the former. The damage was done chiefly by second-brood larvæ which entered thru the roughened parts of the skin, these places affording an easier entrance than the smooth, hard surface of the unrusseted portions. Again, there might have been a less thoro covering of poison over this part of the apple, due to the malformation of the fruit after the spraying was done.

Considerable injury to foliage also occurred on the Bordeaux plats.

EXPERIMENTS IN 1914

It was planned to follow the same general methods as in 1913 except at the Station. The Bordeaux was made by placing the copper sulphate in the tank and diluting, then adding the diluted lime. At the Station, the ingredients were diluted and poured together into the spray tank.

TABLE 43—*Spray schedule*

Date Spray	April 24 Cluster-bud	May 15 Petal-fall	May 25 10-days	June 12 25-days	June 22 35-days	July 14 2d-brood
Plat 1.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	.....	.....	LS-Pb 1.008-2	LS-Pb 1.008-2
2.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	.....	LS-Pb 1.008-2	.....	LS-Pb 1.008-2
3.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	LS-Pb 1.008-2	.....	.....	LS-Pb 1.008-2
4.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	.....	.....	Bx-Pb 3-3-2-50	LS-Pb 1.008-2
5.....	Bx Pb 4-6-2-50	LS-Pb 1.008-2	.....	Bx-Pb 3-3-2-50	.....	LS Pb 1.008-2
6.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	Bx-Pb 3-3-2-50	.....	.....	LS-Pb 1.008-2

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations are in percentages*

Variety	Plat	Codling moth	Curculio worm and sting	Scab	Blotch	Spray injury	Sound fruit
Ben Davis...	1	50.00	.39	1.04	.91	3.50	45.21
	2	38.85	.0	.98	.37	2.96	56.83
	3	34.09	.0	.34	.49	4.96	60.80
	4	29.72	.03	.30	.35	6.78	64.53
	5	31.02	.016	.25	.13	7.39	61.41
	6	31.66	.0	.73	.0	3.91	64.97
	check	66.32	2.58	10.60	10.74	.....	31.85
Mo. Pippin...	1	31.27	.02	.85	2.95	1.15	64.98
	2	28.66	.0	.54	2.16	2.39	67.02
	3	28.07	.0	.32	2.97	1.60	69.24
	4	27.06	.0	.41	.85	.97	71.11
	5	21.09	.01	.15	.86	1.77	76.64
	6	39.07	.0	.12	.37	2.57	58.01
	check	77.58	2.67	12.48	13.08	.....	16.77
Ben Davis Mo. Pippin...	1	32.95	.059	.86	2.76	1.36	63.20
	2	31.60	.0	.67	1.65	2.55	63.37
	3	30.25	.0	.33	2.07	2.82	66.18
	4	28.24	.016	.36	.63	3.53	68.21
	5	25.35	.014	.19	.55	4.18	70.11
	6	37.50	.0	.25	.29	2.85	59.50
	check	74.26	2.65	11.93	12.39	.....	21.22

No sooty blotch or rust present.

At Beatrice (table 43), there was little difference in the efficiency of the two fungicides except in the control of blotch. Again Bordeaux proved superior to lime sulphur for this purpose. However, the difference in efficiency was only about 11 per cent. There was practically no difference in the amount of spray injury on the fruit. Here dry weather followed each application. There was more injury to the foliage from using lime sulphur than Bordeaux. The damage to foliage noted on the lime sulphur plats greatly resembled that of the Bordeaux plats in that there were the same characteristic brown spots on the leaves. However, the spots were larger and more irregular. In addition, the leaves were burned at the edges and at the tips.

TABLE 44—*Spray schedule*

Date Spray	April 25 Cluster-bud	May 15 Petal-fall	June 14 Three-weeks	July 15 Second-brood
Plat 1	LS-Pb 1.01-2	LS-Pb 1.008-2	LS-Pb 1.008-2	Bx-Pb 3-4-2-50
2	LS-Pb 1.01-2	LS-Pb 1.008-2	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50
3	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50
4	LS-Pb 1.01-2	LS-Pb 1.008-2	LS-Pb 1.008-2	LS-Pb 1.008-2

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations are in percentages*

Variety	Plat	Codling moth	Curculio worm and stings	Scab	Spray injury	Sound fruit
Ben Davis Winesap	1	58.01	.0	.09	4.00	38.33
	2	50.27	.0	.10	3.59	46.68
	3	49.65	.0	.07	4.56	46.99
	4	53.47	.0	.14	4.97	46.36
	check	93.91	2.54	1.90	.....	4.13

No blotch or rust was present.

At Lincoln (table 44), there is little evidence in favor of either fungicide except in injury to the foliage. Here lime sulphur did more damage than Bordeaux. The weather at this place was dry after each application.

TABLE 45—*Spray schedule*

Date Spray	April 30 Cluster-bud	May 20 Petal-fall	June 18 3-weeks	July 20 Second-brood
Plat 1.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	LS-Pb 1.008-2	Bx-Pb 3-4-2-50
2.....	Bx-Pb 4-6-2-50	LS-Pb 1.008-2	LS-Pb 1.008-2	Bx-Pb 3-4-2-50
3.....	LS-Pb 1.01-2	LS-Pb 1.008-2	LS-Pb 1.008-2	LS-Pb 1.008-2
4.....	LS-Pb 1.01-2	LS-Pb 1.008-2	LS-Pb 1.008-2	LS-Pb 1.008-2

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations in percentages*

Variety	Plat	Codling moth	Curculio worm and sting	Scab	Sooty blotch	Spray injury	Sound fruit
Ben Davis Winesap	1	23.02	.07	2.42	.0	1.61	74.68
	2	24.13	.10	3.16	1.09	4.82	66.70
	3	27.51	.21	1.99	.0	2.06	68.47
	4	23.29	.13	1.31	.23	2.74	73.61
	check	82.44	2.06	24.47	.76	.....	9.99

No blotch or cedar rust was present.

At Seward (table 45), the evidence is again little in favor of either fungicide. No wet weather was encountered for several days after each application. Again lime sulphur caused more injury to the foliage than did Bordeaux.

EXPERIMENTS IN 1915

Experiments were conducted only at Beatrice this year. The test was primarily one of studying the effect of Bordeaux rather than one of comparison of Bordeaux and lime sulphur, tho the data afford some opportunities for comparison.

At Beatrice (table 46), a comparison of the two fungicides for the cluster-bud spray favors lime sulphur as an insect repellent. However, this is not in accordance with previous tests.

Here again Bordeaux did more injury when applied early than when applied later in the season. Considerable Bordeaux injury was noted on the foliage.

TABLE 46—*Spray schedule*

Date Spray	April 24 Cluster-bud	May 5 Petal-fall	May 24 14-days	June 7 21-days	June 21 35-days	Aug. 10 2d-brood
Plat 1	Bx-Pb	LS-Pb	LS-Pb	.....	.....	LS-Pb
2	4-4-1.5-50	1.009-1.5	1.009-1.5	.....	.....	1.008-1.5
3	LS-Pb	LS-Pb	LS-Pb	.....	.....	LS-Pb
4	1.01-1.5	1.009-1.5	1.009-1.5	.....	.....	1.008-1.5
5	LS-Pb	LS-Pb	Bx-Pb	.....	.....	LS-Pb
6	1.01-1.5	1.009-1.5	4-4-1.5-50	.....	.....	1.008-1.5
7	LS-Pb	LS-Pb	.....	Bx-Pb	.....	LS-Pb
8	1.01-1.5	1.009-1.5	.....	4-4-1.5-50	.....	1.008-1.5
9	LS-Pb	LS-Pb	LS-Pb	.....	Bx-Pb	Bx-Pb
10	1.01-1.5	1.009-1.5	1.009-1.5	.....	4-4-1.5-50	4-4-1.5-50
11	LS-Pb	LS-Pb	LS-Pb	.....	Bx-Pb	LS-Pb
12	1.01-1.5	1.009-1.5	1.009-1.5	.....	4-4-1.5-50	1.008-1.5

*Comparison of the effect of Bordeaux and lime sulphur
Tabulations are in percentages*

Variety	Plat	Codling moth	Curculio		Scab	Blotch	Sooty blotch	Spray injury	Sound fruit
			worm	sting					
Ben Davis	1	11.11	.0	8.24	.69	14.80	3.31	5.24	69.85
	2	4.76	.0	4.57	.25	18.04	.0	5.62	67.03
	3	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....
	5	9.08	.0	5.66	1.79	1.57	1.23	7.40	77.91
	6	2.77	.0	5.19	.0	.17	.0	7.50	86.50
	check	32.45	1.81	9.98	85.01	32.35	69.68	.....	2.17
Mo. Pippin	1	5.63	.0	2.98	.13	36.49	5.76	.53	58.01
	2	2.69	.08	3.14	4.47	20.73	7.28	3.31	71.95
	3	4.15	.0	2.52	.0	7.57	1.35	11.09	77.10
	4	4.22	.0	4.29	1.48	1.03	.34	9.50	83.16
	5	3.02	.0	2.88	.0	1.54	.0	7.63	84.99
	6	1.42	.0	2.11	.0	2.85	.20	.78	92.64
	check	27.64	.64	5.56	74.71	55.75	79.65	.....	2.01
Ben Davis Mo. Pippin	1	8.45	.03	5.69	.42	25.32	4.50	2.96	64.11
	2	3.52	.05	3.72	2.77	19.65	4.36	4.24	69.87
	3 ¹	4.15	.0	2.52	.0	7.57	1.35	11.09	77.10
	4 ¹	4.22	.0	4.29	1.48	1.03	.34	9.50	83.16
	5	5.82	.0	4.16	.83	1.55	.57	7.52	81.72
	6	2.04	.0	3.53	.0	1.62	.11	3.87	89.81
	check	30.21	1.26	7.93	80.23	43.24	74.32	.....	2.10

¹No Ben Davis.

INCIDENTAL OBSERVATIONS

Bordeaux is never entirely safe where much rain falls during the time when the spray is on the trees.

Some varieties of apples are injured more than others, but no variety is entirely free. The varieties Early Harvest, Ralls, Rome, Chenango, Snow, Missouri, York, and Maiden Blush are perhaps less seriously injured than are the other well-known varieties of apples, but since they are also less important the question of varietal susceptibility can be given little consideration in attempting to eliminate the trouble.

Bordeaux injury first appears on the fruit as small dark-colored spots regular in outline and occurring singly or in long clusters. Usually injury occurs on the upper side of the fruit but not uncommonly almost the entire surface is covered. Soon after the spots are first noticed the skins become roughened. Small ridges or veins connect the different spots so that the skin presents a corky, netted appearance. In cases of severe injury, the apples

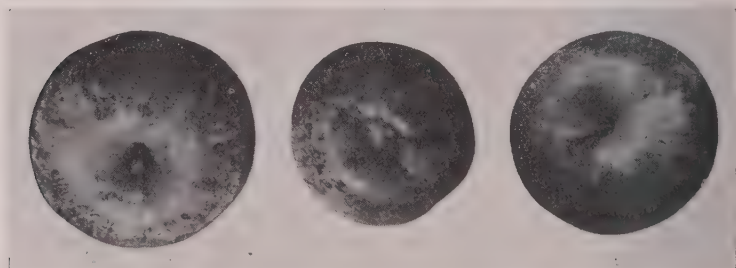


Fig. 15—A light case of Bordeaux injury on fruit

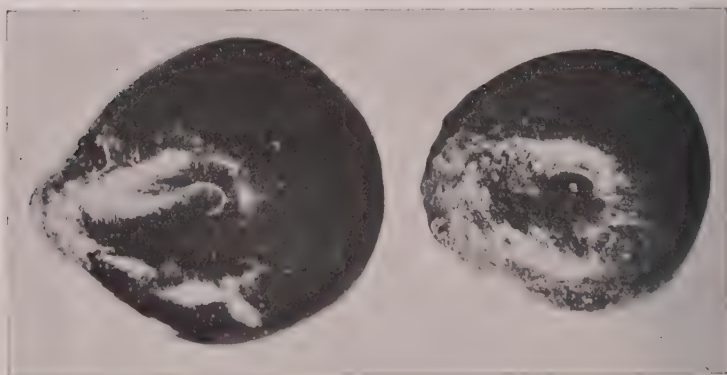


Fig. 16—A severe case of Bordeaux injury on fruit

are often distorted in shape. The growth of the cuticle is checked, while the inner tissues continue to grow. This causes the apple to become lopsided, and often causes cracking similar to that caused by scab and blotch.

On the leaves, Bordeaux injury resembles to some extent the injury caused by some fungi. Brown spots of dead tissue 3 or 4 mm. in diameter appear, at first regular, but as the spots increase in size and coalesce, becoming quite irregular. In cases of severe injury, these spots involve one-third to one-half of the area of the leaf, or more. Soon the remaining portions become yellow, then begin to wither and turn brown, until only the midrib and larger veins remain green; then these succumb and the leaves fall. Sometimes the leaves fall before turning brown. The number of leaves affected varies from a few, scattered over the tree, to almost all the leaves on the tree.

Bordeaux injury usually does not occur for several days after the application and if no rain falls may not occur at all. However, as a rule, enough dew collects to cause some injury even in dry weather. On the foliage the injury was found to be more severe when the leaves had been injured by insects, hail, or other causes. This was also true of the fruit after a hailstorm at Florence.

Lime used in excess does not prevent or lessen to any appreciable extent the injury from Bordeaux russetting. Neither is the application of milk of lime to the trees after Bordeaux has been applied of any appreciable benefit, as shown by table 47.

Lime sulphur causes some injury to both fruit and foliage; but, unlike the injury caused by Bordeaux, it appears almost at once. It causes the most severe injury during hot dry weather. This is no doubt due to the oxidation of the tissues.

On the fruit, lime sulphur injury, when not severe, resembles injury caused by Bordeaux, but in more severe cases the injured surface becomes hard and thickened. Unlike the netted appearance formed in Bordeaux injury, the surface is covered by more or less smooth and dark-colored scales, giving the fruit a scurfy appearance. In the most severe cases, cracks appear on the injured surface, usually near the edges but often crisscrossing the entire surface. This injury is no doubt partly due to sun scald before or during the time when the oxidation of the tissues is taking place. That this must be the case is shown by the fact that the most severe injury is always found on the south and west sides of the trees. The injury before spraying or as it appears on unsprayed trees was much less severe and of a different appearance. Sun scald alone appears first as a brownish discolored spot with a fairly distinct margin. Later, in the most severe cases, the skin becomes sunken and remains smooth and dark. Very little cracking

TABLE 47—Effect of using milk of lime after rains on plats sprayed with Bordeaux and of using Bordeaux without lime

Location	Treatment	Applica- tion	Total fruit	Scab	Per cent	Blotch	Per cent	Sooty blotch	Per cent	Spray injury	Per cent
Lincoln											
1.....	3 4-50 Bordeaux	1 2-3 4	1,589	26	1.63	.0	.0	.0	.0	193	12.13
2.....	3-3-50 Bordeaux	1 2-3-4	954	13	1.36	.0	.0	.0	.0	102	10.73
3.....	3 4-50 Bordeaux followed by milk of lime after rains	1 2-3-4	1,313	24	1.37	.0	.0	.0	.0	224	12.8

occurs except at the margin of the injured spot. On the sprayed fruit a much larger area is usually affected. Cracking is more pronounced and scales and rays of russet extend far beyond the limits of the sunken corky spots.

Often the most severe injury did not appear for several days after spraying, or until a period of very hot, dry weather and bright sunshine. However, in such cases the injury was rarely so severe as when the spraying was done during a period of extremely hot, dry weather. Bonns (1912) says that the spray affects only that portion of the fruit which has already been injured by sun scald.

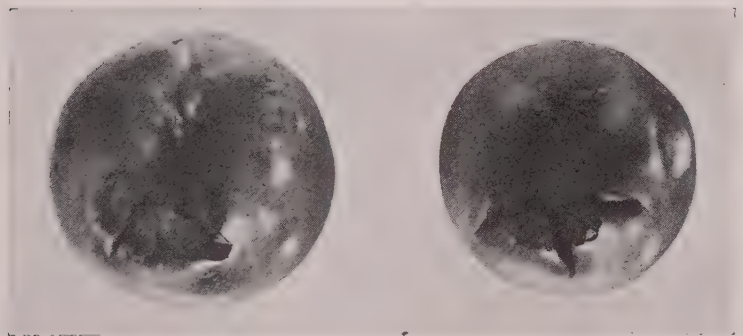


Fig. 17—Lime sulphur injury on fruit

On the foliage, lime sulphur injury appears within the first 12 to 24 hours after applying the spray. The tender new leaves are the first to suffer but in more severe cases the mature leaves are also damaged. The injury appears first at the tips and edges, where the material collects in larger quantities, and gradually extends toward the center of the leaf. Dead, brown spots may also appear over the entire leaf. The general appearance is as tho the leaves had been scorched by fire.

Lime sulphur containing sludge causes more severe burning than where the clear liquid is used. This was demonstrated in a near-by orchard where lime sulphur containing sludge was used on a part of the orchard while the remainder was sprayed with the clear liquid. Both leaves and fruit were damaged where the sludge was used.

Grit or hard materials of any kind in the solution may cause russetting by being thrown against the surface of the fruit with considerable force, thus destroying the waxy covering of the cells or the cells themselves and allowing them to be more easily injured by the corrosive action of the spray.

It is the opinion of the writer that a great deal of the so-called spray injury to the leaves is due to infection by fungous diseases. It was noticed that either Bordeaux and lime sulphur injury was as a rule more conspicuous in the orchards where there was an infection of blotch. This was also true of lime sulphur in 1915 in the orchards where the scab infection was most severe. The spray when applied where infection has occurred finds a ready entrance into the leaves at the infected parts and consequently destroys the contents of the surrounding cells, causing the well-known spotting. This has also been noted consistently in other orchards, the spray injury in the form of spotting of the leaves occurring more abundantly in orchards infected with blotch or scab and appearing in greater numbers after the last spray of the summer.

Hedrick (1907) states that the scab fungus often causes a russet closely resembling spray injury to appear on apples and pears. He also mentions the resemblance of Bordeaux injury on the foliage to the injury caused by species of *Phyllosticta*. Stewart and Eustace (1902) found that the spots caused by Bordeaux injury were free from the pycnidia or *Phyllosticta* in early summer, July 10, but that later the majority of the spots contained a species of *Phyllosticta*, but they raise the question as to whether the fungus does not appear as a saprophyte after the Bordeaux has caused the injury.

As a rule, even where russetting is negligible, fruit sprayed with Bordeaux is not so bright colored and attractive as fruit sprayed with lime sulphur. Tiny gray flecks are scattered over the surface, marring the otherwise smooth, waxy appearance. This condition, however, is not so noticeable where Bordeaux is used during the latter part of the season and is not followed by rain.

SUMMARY

The results of the three years' work with Bordeaux and lime sulphur indicate that Bordeaux is very little if any more effective than lime sulphur as a fungicide under Nebraska conditions, except in the control of apple blotch.

The danger of injuring the fruit which accompanies the use of Bordeaux makes its use inadvisable except where serious infections of blotch occur.

(1907) Hedrick, U. P. Bordeaux injury. New York (Geneva) Exp. Sta. Bul. 287:139.

(1902) Stewart, F. C., and Eustace, H. J. Two unusual troubles of apple foliage. (Pt. ii) New York Sta. Bul. 220:225-233.

Bordeaux injury is most severe during wet weather and on young fruit.

Lime sulphur injury is most severe during dry weather.

The 3-3-50 Bordeaux has proven as efficient for spraying apples as any other formula.

Bordeaux injury cannot be materially reduced by using an excess of lime or by applying lime after spraying with Bordeaux.

HOME BOILED VS. COMMERCIAL LIME SULPHUR

The comparatively high cost of commercial lime sulphur has induced a number of growers to attempt to manufacture their own solution. Such varying degrees of success have accompanied these efforts that it was decided to conduct a series of tests to determine the relative value of the two solutions. Only one year's work is reported.

TABLE 48—*A comparison of the effect of home boiled vs. commercial concentrated lime sulphur*

Variety	Plat	Total fruit	Scab	Per cent	Spray injury	Per cent
Winesap.....	¹ 1	1,893	575	30.38	15	.79
Ben Davis.....	¹	1,705	506	29.68	71	4.16
Winesap.....		1,737	208	11.97	74	4.26
Arkansas.....		926	66	7.13	25	2.70
Jonathan.....		2,415	0	.00	65	2.69
Malinda.....		2,831	63	2.22	651	23.00
Virginia Beauty.....		2,964	177	5.97	292	9.85
Grimes.....		1,506	22	1.46	161	10.69
		15,977	1,617	10.12	1,354	8.49
Winesap.....	¹ 2	1,499	571	38.09	43	2.87
Ben Davis.....	¹	1,871	573	30.62	108	5.77
Winesap.....		1,036	141	13.61	52	5.02
Arkansas.....		658	47	7.14	17	2.58
Jonathan.....		972	1	.10	123	12.65
Malinda.....		2,667	36	1.35	880	33.00
Virginia Beauty.....		1,376	125	9.09	200	14.53
Grimes.....		2,120	32	1.51	359	16.93
		12,199	1,526	12.51	1,782	14.61

Plat 1 was sprayed four times with home boiled lime sulphur, 1.009 specific gravity.

Plat 2 was sprayed four times with commercial lime sulphur made up to the same strength.

¹These trees stood close to check trees which were heavily scabbed.

Altho the evidence in table 48 is not conclusive, it at least indicates that the home boiled product is as effective when properly

made as the commercial brands. Slightly less spray burn was recorded for the plats sprayed with the home boiled solution. If spray injury is due to the rapid oxidation of the sulphur compounds, this might be expected, since of the total sulphur content of the home boiled solution approximately 62.5 per cent was polysulphides, (CaS_5 and CaS_4), while the polysulphides in the commercial solution amounted to approximately 75.4 per cent of the entire sulphur content.

The results shown in tables 31 and 32 are for home boiled lime sulphur.

COMMERCIAL PREPARATIONS SOLD AS FUNGICIDES

Several preparations, sold as fungicides by various companies, have been tried out, but so far nothing has been found to take the place of the two standard fungicides. Several brands of prepared Bordeaux were found to control fungous diseases practically as well as the regular Bordeaux but did considerably more damage to fruit and foliage.

Atomic sulphur and soluble sulphur were used with the results that scab was usually controlled but the damage to fruit and foliage was so great as to make the use of either disastrous. Sulphur in either form would be desirable because of convenience in handling and reduction in freight, could the disagreeable feature of injury to the fruit be eliminated.

PENETRATION VS. MIST SPRAYING

There has been so much discussion in regard to the manner of applying spray materials, so many arguments advanced favoring both high and low pressure solid-stream and hollow-stream nozzles, etc., etc., that it is difficult to determine which method or combination of methods to follow. Unfortunately for the man who studies bulletins from every station, hoping thereby to model his own course of procedure, there is such a wide range of climatic and other conditions that what is true for one section of the country will not obtain for another. Especially is this true in attempting to compare eastern and western methods of fruit growing. And, while the penetration method of spraying, i.e., applying the liquid with solid-stream nozzles under high pressure, gives good results under Washington conditions, it does not necessarily follow that it will give equally good results under such conditions as obtain in the Middle West.

The foregoing report on codling moth control shows that the spray applied as a coarse mist under 225 to 250 pounds pressure is as effective for the calyx application as where applied with the

solid-stream type of nozzle under the same or higher pressure. The following tables afford a comparison for each of the principal sprays.

TABLE 49—*Nemaha spray schedule*

	Cluster-bud	Petal-fall	3-weeks	Second-brood	
Plat 1.	Bx-3-4-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	Bx-Pb 3-4-2-50	mist
2.	Bx-3-4-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	Bx-Pb 3-4-2-50	penetration
3.	LS-Pb 1½-2-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	mist
4.	LS-Pb 1½-2-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	LS-Pb 1½-2-50	penetration

Comparison of the effects of mist and penetration methods of applying spray materials, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Ben Davis.. {	1	15.46	1.74	7.75
	2	10.34	1.40	22.59
	3	4.94	1.29	1.60
	4	11.76	2.47	14.36
Winesap... {	1	14.08	2.07	6.80
	2	11.72	1.83	20.13
	3	8.94	2.44	2.92
	4	11.32	1.18	14.53
Jonathan.. {	1	13.74	2.00	9.23
	2	5.20	1.37	22.32
	3	4.88	1.38	1.62
	4	11.66	2.50	14.05
Combined varieties... {	1	14.34	1.96	7.91
	2	9.24	1.58	21.41
	3	6.69	1.83	2.19
	4	11.53	1.91	14.33

At Nemaha (table 49), mist nozzles were used for each spray on plats 1 and 3 except the petal-fall application, when Bordeaux nozzles were used. Practically no difference was found except in the amount of spray injury, which was considerably more on the penetration plats in the case of both Bordeaux and lime sulphur than on the mist plats.

TABLE 50—*Lincoln spray schedule*

	Cluster-bud	Petal-fall	3-weeks	Second-brood	
Plat 1.	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50	Bx-Pb 3-4-2-50	mist
2.	Bx Pb 3-4-2-50	Bx-Pb 3-4-2-50	Bx Pb 3-4-2-50	Bx-Pb 3-4-2-50	penetration

Comparison of the effects of mist and penetration methods of applying spray materials, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Ben Davis	1	21.37	.65	21.21
Jonathan	2	20.10	.57	41.60
	check	39.58	34.85	.....

At Lincoln (table 50), all the applications on plat 1 were made with mist nozzles and all on plat 2 with Bordeaux nozzles. Again no difference was found except in the amount of spray injury, which was 20 per cent greater on the penetration plat.

TABLE 51—*Beatrice spray schedule*

	Cluster-bud	Petal-fall	25-days	Second-brood	
Plat 1.	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	Pb-LS 2-1.008	mist
2.	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	Pb-LS 2-1.008	penetration

Comparison of the effects of the mist and penetration methods of spraying, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Ben Davis	1	47.63	.53	3.35
Mo. Pippin	2	47.90	.31	8.39
	check	77.16	24.32	.....

At Beatrice (table 51), mist nozzles were used thruout on plat 1. The only difference between the two plats was in the amount of spray injury. There was 5 per cent more spray injury on the penetration than on the mist plat.

TABLE 52—*Lincoln spray schedule*

	Cluster-bud	Petal-fall	25-days	35-days	2d-brood	
Plat 1...	Bx-Pb 4-6-2-50	Pb-LS 2-1.008	Bx-Pb 3-4-2-50	.....	Bx-Pb 3-4-2-50	mist
2...	Bx-Pb 4-6-2-50	Pb-LS 2-1.008	Bx-Pb 3-4-2-50	.....	Bx Pb 3-4-2-50	penetration
3...	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	.....	Pb-LS 2-1.008	mist
4...	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	.....	Pb-LS 2-1.008	penetration

Comparison of the effects of the mist and penetration methods of spraying, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Ben Davis Winesap...	1	49.69	.07	4.56
	2	48.39	.17	4.86
	3	53.52	.14	4.97
	4	53.85	.15	5.51

At Lincoln (table 52), mist nozzles were used on plats 1 and 3 except for the petal-fall spray, when Bordeaux nozzles were used. Bordeaux nozzles were used thruout on plats 2 and 4. This table furnishes no evidence in favor of either method.

TABLE 53—*Seward spray schedule*

	Cluster-bud	Petal-fall	3-weeks	Second-brood	
Plat 1.....	Bx-Pb 4-6-2-50	Pb-LS 2-1.008	Pb-LS 2-1.008	Bx-Pb 3-4-2-50	mist
2.....	Bx-Pb 4-6-2-50	Pb-LS 2-1.008	Pb-LS 2-1.008	Bx-Pb 3-4-2-50	penetration
3.....	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	Pb-LS 2-1.008	mist
4.....	Pb-LS 2-1.009	Pb-LS 2-1.008	Pb-LS 2-1.008	Pb-LS 2-1.008	penetration

Comparison of the effects of mist and penetration methods of applying spray materials, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Ben Davis Winesap . . .	1	23.10	2.42	1.61
	2	24.26	4.25	3.16
	3	27.73	1.99	2.06
	4	23.41	1.54	2.74
	check	84.50	25.23	.....

At Seward (table 53), no evidence could be found favoring either method of spraying. Poor pressure was maintained thruout, which may account for the lack of difference in the amount of injury. Bordeaux nozzles were used for the petal-fall application on plats 1 and 3. Mist nozzles were used for the remaining applications. Bordeaux nozzles were used thruout on plats 2 and 4.

TABLE 54—*Beatrice spray schedule*

	Cluster-bud	Petal-fall	14-days	Second-brood	
Plat 1	Pb-LS 1.5-1.01	Pb-LS 1.5-1.009	Pb-LS 1.5-1.009	Pb-LS 1.5-1.009	mist
2	Pb-LS 1.5-1.01	Pb-LS 1.5-1.009	Pb-LS 1.5-1.009	Pb-LS 1.5-1.009	penetration

Comparison of the effects of mist and penetration methods of spraying, by percentages

Variety	Plat	Insect injury	Fungous injury	Spray injury
Mo. Pippin {	1	5.92	32.48	3.31
	2	5.73	22.84	11.21
	check	33.54	210.60	.....
Ben Davis {	1	6.11	28.19	5.04
	2	5.89	23.29	10.54
	check	44.61	188.15	.....
Mo. Pippin Ben Davis {	1	6.00	30.66	4.05
	2	5.79	23.00	10.97
	check	39.46	198.60	.....

At Beatrice (table 54), there was a slight difference in favor of the penetration method of spraying as shown by the amount of fungous infection controlled, but this was balanced by the greater

amount of spray injury caused by this method. Plat 1 was sprayed with mist nozzles at each application and plat 2 with Bordeaux nozzles.

SUMMARY

The evidence presented by the data on codling moth control and that shown in the foregoing tables indicate that more injury is done by using solid-stream nozzles than by using those of the hollow-stream type, while there is practically no more efficiency secured. Even for the petal-fall spray nothing is gained by using the Bordeaux type of nozzle. The filling of all calyx cups and the thoro covering of all parts of the tree, fruit, and foliage with the least expenditure of labor and material and with a minimum amount of injury to the fruit constitutes efficiency in spraying. Coarse mist nozzles operating under 225 to 250 pounds pressure will throw a penetrating heavy mist several feet thru the foliage of an ordinary tree and will fill the calyx cups as readily and cover all parts of the foliage more evenly and thoroly than will the Bordeaux type of nozzle.

To prevent injury, the material should be applied evenly, so that the liquid will not collect in large drops or run off. There is less danger of missing any part of the tree, and the fruit is not so liable to be russeted by the hard particles in the spray, when applied in this way.

The relative costs of the two methods of spraying will be discussed later.

CUMULATIVE EFFECTS OF SPRAYING

The argument is often advanced that it does not pay to spray when a crop is not expected or when the insect infestation or the fungous infection is light. This is a fallacy. The orchardist cannot afford to neglect spraying just because there is no promise of immediate returns. Spraying will more than pay expenses in the benefit to the following year's crop. At Florence in 1913 only a part of a 30-acre orchard was sprayed. The whole orchard was sprayed in 1914 and 1915, but at harvest time in 1915 the effect of the thoro spraying received by but a part of the trees in 1913 was still decidedly noticeable. The effects were so evident that the packers, who were not acquainted with the facts of the case, found a decided difference in the grades of fruit from the two parts of the orchard.

The following tables also indicate that the cumulative effects make spraying decidedly worth while even in an "off year."

TABLE 55—*Cumulative effect of spraying
(by percentages)*

Variety	Plat	Insect injury	Fungous injury	
Mo. Pippin	1	5.73	22.84	.....
	2	12.83	57.32	.....
	check	33.54	210.58	.....

Both plats in table 55 were sprayed in 1915, but only plat 1 received any spray in 1914. The plats were only two rows apart in the same orchard. In recording fungous injury, 210 per cent was secured by adding together the apples affected by scab, blotch, and sooty blotch.

The foregoing data, while not exhaustive, serve to indicate the importance of continued effort in insect and disease control.

TABLE 56—*Cumulative effect of spraying
(by percentages)*

Variety	Plat	Insect injury	Fungous injury	
Jonathan....	1	9.79	30.37	.....
Ben Davis...	1	19.65	50.34	.....
	total	11.15	33.12	.....
Ben Davis....	2	110.42	192.02	.....
Jonathan.....	2	77.44	99.95	.....
	total	94.62	147.90	.....

At Omaha (table 56), neither plat was sprayed in 1915, the year in which the data were taken. Plat 1 was sprayed for five consecutive years prior to 1915. Plat 2 has never been sprayed. The plats were situated one-half mile apart.

COST OF SPRAYING

Accurate accounts were kept of all labor and materials used in spraying thruout the three seasons' work. In computing costs of spraying, averages were made for each type of machine, for all Bordeaux schedules, for lime sulphur schedules, and for the mist and penetration schedules. In computing the cost of lime sulphur the 1½-2-50 formula was used, the cost of poison being included. In computing the cost of Bordeaux and arsenate of lead the 3-4-2-50 formula was used.

The following tables show the comparative efficiency of the general types of spraying machinery as well as the cost of the spraying.

TABLE 57.—Comparative cost of spraying with machines of various capacities
A.—50-gallon barrel pump. 2- to 3-gallons-per-minute capacity. Two men and one team used

TABLE 58—Comparison of the mist and penetration methods of spraying, using lime sulphur
Power pump. 10- to 12-gallons-per-minute capacity. Three men and one team used

A

No. of spray	No. leads of hose	Kind and No. of nozzles	Pres- sure	Distance to haul	No. trees sprayed per day	Amount to tree in gals.	COST PER TREE				TOTAL
							LABOR		MATERIAL		
							Men	Teams	Fungi- cide	Insecti- cide	
1	2	4 mist	225	1 mile	533	3.0	.0113	.00281	.0108	.0084	.0331
2	2	4 "	250	"	355	7.5	.014	.00422	.0270	.021	.06622
3	2	4 "	225	"	355	4.5	.014	.00422	.0162	.0126	.04702
4	2	4 "	220	"	400	4.0	.015	.00375	.0144	.0112	.04435
							Total cost		.1909		

B

1	2	4 mist	225	1 mile	500	4.0	.012	.003	.0144	.0112	.0406
2	2	4 "	250	"	325	8.5	.0184	.0046	.0306	.0238	.0774
3	2	4 "	200	"	400	5.0	.015	.00375	.018	.014	.05075
4	2	4 "	200	"	400	5.0	.015	.00375	.018	.014	.05075
							Total cost				.21950

C

1	2	4 Bx.	225	1 mile	320	6.5	.0187	.00468	.0234	.0182	.06498
2	2	4 "	250	"	220	9.5	.0272	.00680	.0342	.0266	.0948
3	2	4 "	225	"	320	7.6	.0187	.00468	.0273	.02128	.07196
4	2	4 "	225	"	266	7.5	.0225	.00563	.0270	.021	.0761
							Total cost				.30784

D

1	2	4 Bx.	225	1 mile	400	5.0	.015	.00375	.018	.014	.05079
2	2	4 "	250	"	250	8.0	.0240	.00600	.0288	.0224	.08120
3	2	4 "	225	"	350	6.0	.0171	.00427	.0216	.0168	.06977
4	2	4 "	225	"	350	6.0	.0171	.00427	.0216	.0168	.06977
							Total cost				.27149

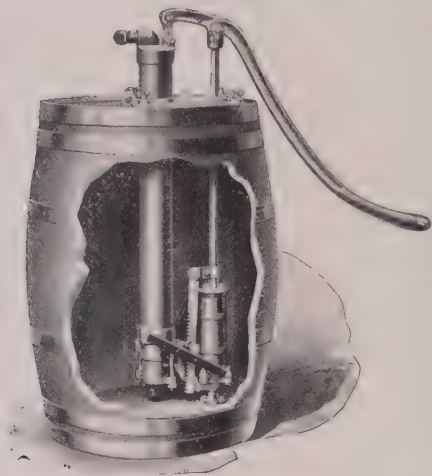


Fig. 18—A good type of barrel pump

Table 57 A shows the average cost of spraying with a barrel pump similar to fig. 18. An outfit of this kind is efficient for an orchard of 300 trees or less, considering 20 to 24-year-old trees as an average.



Fig. 19 A hand pump affording greater pressure than the pump shown in Figure 18

Table 57 B shows the average cost of spraying with the larger capacity hand pumps similar to fig. 19. A machine of this capacity is efficient for an orchard of 300 to 400 trees.

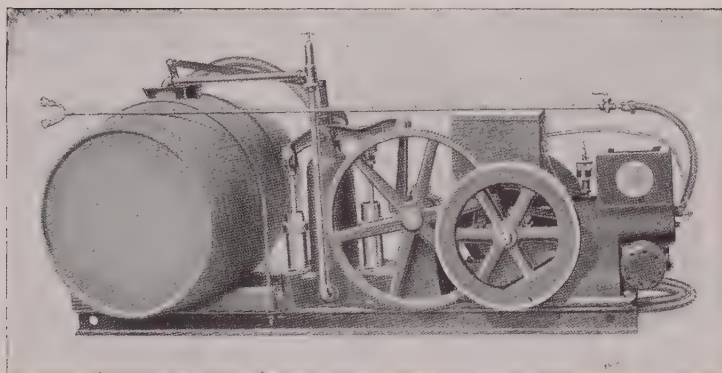


Fig. 20—A small power outfit which may be operated by one man alone

Table 57 C shows the average cost of spraying with the one-man type of power sprayer similar to fig. 20. A machine of this capacity is efficient for orchards of from 400 to 600 trees.

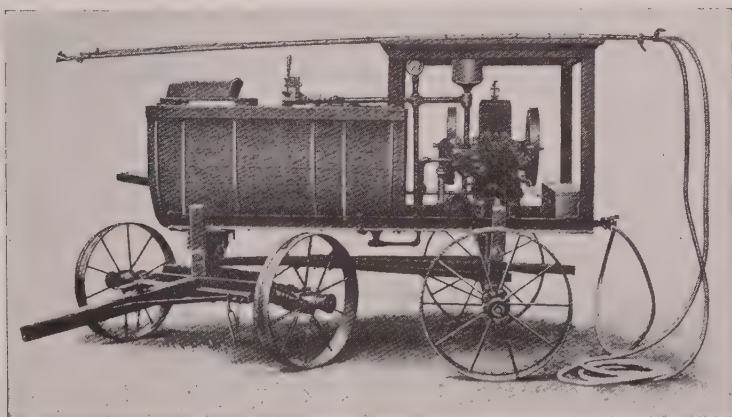


Fig. 21—Power outfit of the horizontal pump type; 8- to 10-gallons-per-minute capacity

Table 57 D shows the average cost of spraying with a type of machine similar to that shown in figs. 21 and 22. A machine of this capacity is efficient for an orchard of 600 to 1,000 trees.



Fig. 22—A Duplex power outfit of the same capacity as the machine shown in figure 21

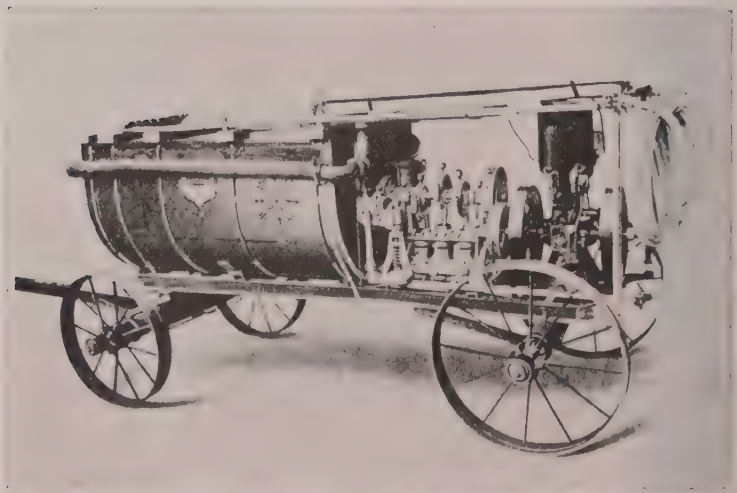


Fig. 23 A Triplex machine of 10- to 12-gallons-per-minute capacity

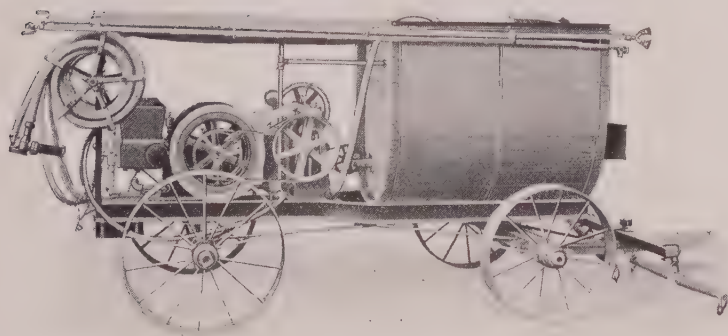


Fig. 24—A Triplex machine of the same capacity as the one shown in figure 23

Tables 58 and 59 show the cost of spraying with the large capacity machines similar to fig. 23 or similar to fig. 24, but of larger capacity. Machines of this capacity are efficient for 1,000 to 2,000 trees.

Efficient service cannot be secured where the capacity of the machine is too small to spray the orchard in five or six full days of good weather. The capacity of the machine needed may be determined by the length of time the calyx cups remain open. This is usually 7 to 10 days. A single machine may be used to spray more than this if the varieties are so arranged that one part of the orchard comes into bloom later than another; but with our standard varieties of apples, not more than two or three days can be gained in this way. It is little wonder that the fruit grower who sprays (?) 50 to 100 acres of orchard with one machine fails to get results.

The cost of spraying with lime sulphur is shown in table 58. This table also shows the comparative cost of the mist and the penetration methods of spraying. The penetration method is more expensive from the fact that more time is consumed in applying the spray and for the reason that more material is used. That this excess is wasted is shown by the fact that the efficiency was no higher than when the spray was applied as a mist. This superfluous amount of material may account for a part of the excessive spray injury caused by the penetration method of spraying.

Table 59 shows the cost of spraying with Bordeaux as well as a comparison of the mist and penetration methods of spraying.

Little difference is shown between the actual cost of spraying with Bordeaux and with lime sulphur as indicated by the tables. The cost of material for the former is somewhat less; but the additional labor of making it brings the cost up equal to that of lime sulphur.

RESULTS OF SPRAYING BASED ON COMMERCIAL RETURNS

It is impossible to make a fair comparison of commercial returns from spraying in widely separated orchards, in the treatment of which the only thing in common is spraying. For instance, the percentage of fruit free from insect or fungous injury may be higher in a sod orchard than in an orchard under cultivation, but when the fruit is graded the returns from the cultivated orchards are larger because the individual apples are larger. Again, a well-pruned orchard may show higher returns when the fruit is graded than an unpruned orchard in spite of the fact that the number of sound apples in the latter is much greater. As in the first instance, the size of the individual apples is the determining factor. In table 59, commercial grades of the sprayed plats are compared with commercial grades from check trees in the same orchard. No attempt is made to compare the results from the different orchards.

TABLE 60—Commercial grades of picked fruit from plats showing best results for the different seasons

Location	Plat	Treatment	Application					Variety	Percentage grades of picked apples				
			Cluster-bud	Petal-fall	7-14 days	21-35 days	2d-brood		3d-brood	Average fruit to tree in bu.	No. 1	No. 2	No. 3	Culls	Value
Wymore	1	LS Pb 1-5 2-50.	1	2				Pen Davis Mo. Pippin	15.25	2-2.13	19.67	8.19	
	check	Bx-Pb 3-4-2-50.			3	4	6.75		2-2.22	33.33	14.44		
1914													
Beatrice	2	LS Pb 1.009 2-50		2				Ben Davis Mo. Pippin	9.		14.01	7.7	
	check	Bx-Pb 3-4-2-50.	1		3	4	.75		278.28	38.5	61.5		
Lincoln	3	LS-Pb 1.009-2-50.	1	2		3	4	Ben Davis Winesap Jonathan	17.00 4.25	31.9	12	6.1	
	check								4.25		27.6	72.4	
1915													
Beatrice	4	LS-Pb 1.009-2.5-50.	1	2	3			Pen Davis Mo. Pippin	10.3	53.49	34.72	10	1.79
	check	Bx-Pb 3-4-2.5-50.				4	5		1.75	3.33	4.44	3.88	33.33
Omaha	5	LS-Pb 1.009-2.5-50.	1	2		3	4	Pen Davis Jonathan	21.7	35.2	33.3	10.41	1.04
	check								6.8	16.00	40.00	38.86	5.14
Lincoln	6	HBL-S-Pb 1.009-2.5-50	1	2		3	4	Ben Davis Winesap Jonathan	19.2	27.55	11.63	.82	
	check								6.5	14.57	52.98	32.45	

¹Blotch was present in these orchards, consequently lime sulphur did not give as good results as where Bordeaux was used the latter part of the season.

²Grades Nos. 1 and 2 were combined.

In computing the value, the actual selling price of the fruit was taken. The culls were not considered since they were not sold. The net gain per tree from spraying these plats may be found as follows:

Plat 1—	Total value of fruit.....	\$12.05
	Value of fruit on check plat.....	2.28
	Difference.....	9.77
	Cost of spraying.....	.29
	Net gain from spraying.....	9.48
Plat 2—	Total value of fruit.....	7.47
	Value of fruit on check.....	.10
	Difference.....	7.37
	Cost of spraying.....	.25
	Net gain from spraying.....	7.12
Plat 3—	Total value of fruit.....	14.63
	Value of fruit on check.....	.40
	Difference.....	14.23
	Cost of spraying.....	.26
	Net returns from spraying.....	13.97
Plat 4—	Total value of fruit.....	10.59
	Value of fruit on check.....	.21
	Difference.....	10.38
	Cost of spraying.....	.24
	Net gain from spraying.....	10.14
Plat 5—	Total value of fruit.....	26.31
	Value of fruit on check.....	5.66
	Difference.....	20.65
	Cost of spraying.....	.25
	Net gain from spraying.....	20.40
Plat 6—	Total value of fruit.....	17.55
	Value of fruit on check.....	2.14
	Difference.....	15.41
	Cost of spraying.....	.26
	Net gain from spraying.....	14.15

The above yields no doubt appear high, and would be high were we considering the average of the whole orchard, but it must be remembered that the trees under observation were chosen because of their uniformly good state of health, shape, size, and fruitfulness. Considering all the trees in the various orchards, the net gain per tree on the sprayed portions was approximately one-half the amount shown above.

GENERAL SUMMARY AND RECOMMENDATIONS

Three sprays are required during a normal season to control an ordinary infestation of codling moth. The first spray should be applied immediately after two-thirds to three-fourths of the petals have fallen. The spray should be applied as a coarse mist, directly against the face of the open calyces. In order to apply the spray properly the greater part of the spraying should

be done from the tower. A good arrangement, where the trees are large, if a large capacity machine is used, is for two men to work from the tower and one from the ground. The material should be applied downward with a stroking motion of the rod, beginning at the extreme tip of the branches and following down to the trunk. In this way there is a minimum danger of missing any of the calyces. More material is needed for this application than for any other. The pressure should be 225 to 250 pounds. The next spray should be applied about three weeks later and should consist of a fine mist. The paramount object of this application is to cover thoroly all growing parts of the tree. The material should be directed both above and below with long stroking motions, beginning at the tips of the branches. The exact time for applying this spray is immediately after the moths begin to deposit their eggs, and may be determined as indicated on page 12.

The third spray for codling moth should be applied immediately after the eggs, from which the second-brood larvæ hatch, are laid and should be applied in the same manner as the preceding spray.

In abnormal seasons, like that of 1914, when owing to favorable conditions the moths emerge early and multiply rapidly, a third-brood spray is necessary.

Practically no difference was found in the effectiveness of any of the standard brands of arsenate of lead.

Two pounds of arsenate of lead "paste" or $1\frac{1}{4}$ pounds of arsenate of lead powder has been found to be as efficient as more.

In spraying for the control of the plum curculio, the work must be done early in the season. It was found necessary to apply one spray before the flowers open. The time for the remaining sprays corresponds so closely to the first two codling moth sprays that the schedule for that insect may be adopted. It has been shown, however, that a spray as late as the second-brood codling moth application is as a rule of little value in controlling the curculio.

In an average season, in orchards where clean culture and thoro spraying have not greatly reduced the infection three sprays are necessary to control the primary infection of apple scab. The first spray should be applied before the blossoms open and may be combined with the first spray for plum curculio. The next two sprays correspond so closely with the first and second sprays for codling moth, and the second and third for curculio that the poison and fungicides may be combined. In case of a heavy secondary infection, such as occurred in 1915, a later spray, corresponding so closely to the time of the second-brood codling moth application that it may be combined with it, is necessary.

The first spray for the control of blotch should be applied about three weeks after the petals fall and may be combined with the second codling moth application. In cases of severe infection another application may be necessary 15 to 20 days later.

Rust and sooty blotch are usually controlled incidentally.

Practically no difference has been found in the efficiency of Bordeaux and lime sulphur in controlling fungous diseases, except in the case of apple blotch. For controlling this disease Bordeaux is much more efficient than lime sulphur. On the other hand it is also much more liable to injure the fruit when used early in the season. In fact more or less danger accompanies its use at any time.

No way of eliminating Bordeaux injury has been found. Lime used in excess is of no value. The application of milk of lime, following rains, to trees which have been sprayed with Bordeaux does not lessen the injury to any appreciable extent.

It was found practicable to interchange Bordeaux and lime sulphur sprays in a schedule, so as to afford a maximum amount of control with a minimum amount of injury. Bordeaux may be used with little injury for the first or cluster-bud spray, and as a rule not very much injury accompanies its use three weeks after the petals fall or later, unless wet weather follows its application. Bordeaux should be used for the 3-weeks spray where blotch infection is heavy, but in case of wet weather it would be best to use lime sulphur instead and as soon as a period of fair weather arrives apply Bordeaux. Where the 35-days spray is applied for blotch, Bordeaux should be used.

Home boiled lime sulphur has been found as efficient a fungicide as the ordinary commercial product. However, only the clear liquid should be used, as the coarse particles in the sludge may, when thrown with force against the tender skin of the fruit, cause russetting.

Among the various new fungicides which were tried, none were found to be in any way superior to the two standard fungicides now in use. Bordeaux arsenate, Pyrox, and tuber tonic proved effective in controlling fungi, but all caused considerable damage to fruit and foliage, and are more expensive than Bordeaux.

Soluble sulphur and atomic sulphur proved effective in controlling apple scab but both did too much damage to fruit and foliage to warrant their use in their present form. Both would be desirable sprays could this disagreeable feature be eliminated.

Spray applied with hollow-stream nozzles was found fully as effective as when applied with the solid-stream type. More spray injury accompanies the use of the latter, and the unavoidable waste of material makes their use more expensive.

The results of the last three seasons indicate that while it is sometimes possible to omit either the fungicide or the insecticide in the first spray, or to omit the first spray altogether, without suffering serious loss, it is never safe to do so. It is more hazardous to omit the fungicide than the insecticide. The omission of the fungicide in 1915 would have been almost disastrous in the average orchard, and the omission of the insecticide would have meant the loss of several bushels of fruit out of every hundred bushels.

There is no doubt that the beneficial effects of spraying are noticeable for more than a single season and that thoro spraying for a number of years will greatly lessen insect infestation and disease infection.

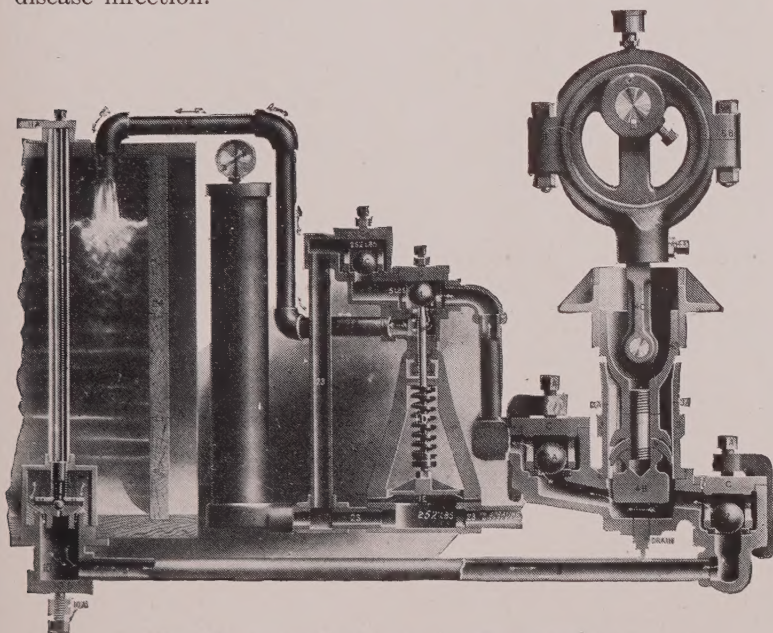


Fig. 25—An excellent type of pressure regulator

It has been shown that clean culture is of paramount importance in controlling plum curculio and apple scab.

The capacity of the spraying machine must be gauged by the size of the orchard and the length of time available for applying the petal-fall spray. The time from the falling of the petals to

the complete closing of the calyces is usually seven to ten days. It is not safe to attempt to spray more trees than can be covered in five or six full days with one machine.

Power machines are the most satisfactory where the orchard is large enough to warrant their use, tho not necessarily more efficient than a good type of hand pump outfit when the latter is properly used. With any outfit the nozzle capacity must be regulated to fit the capacity of the pump. No outfit will do good work when the pump is unable to supply the liquid fast enough to maintain a good pressure. It makes little difference whether a double acting horizontal pump or an upright duplex or triplex pump is used if the capacity is large enough and it is well made, provided plenty of power is supplied to operate it at full capacity and the outfit is not too heavy. The outfit shown in fig. 21 is of the horizontal type and the one shown in figs. 23 and 24 belongs to the upright plunger type. However excellent in all other ways, an outfit is not dependable unless it has a good pressure regulator. One of the best pressure regulators is shown in detail in fig. 25.

It must be remembered that efficiency in spraying is secured only by doing the work thoroly and at a time that will prevent infestation and infection. Protection by spraying is preventive rather than curative. A spray applied at the wrong time is little better than no spray. Spraying in a half-hearted way is often worse than no spray. It costs money but does no good. It is cheaper to buy efficient machines than to "kill time tinkering" with a poor machine.

